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Culp, Andrew J., Machinist, 1427 N. 7th st. C.
Curtis, H. W., Picture Frames, 50 N. 6th st. C.
Curtis, John, N.W. 17th and Cayuga sts. L.
Custer, C., Mill Wright, 662 N. 10th st. C

Da Costa, James S., 334 S. Front st. C.
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Dallett, Thos. H., Soaps, 951 Ridge av. 2nd.
Davis, A. B., Scale Maker, 1600 Wallace st. C.
Davis, Courtland H., 1631 Franklin st. 1st.
Davis, Henry, Merchant, 353 N. 3d st. C.
Davis, H. C., Penn Mines, Mich. C.
Davis, Samuel H., Manufacturer, Leopard and Otter sts. C.
Davis, Wm. H., Merchant. L.
Davidson, Robt. B., Broker, 313½ Walnut st. L.
Dawson, Wm., Carpenter, 515 N. 10th st. C.
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De Haven, Isaac Norris, Engineer, 222 N. 21st st. C.
Deiterich, Emile F. L.
Deitz, W. H., Plumber, 312 Dickinson st. C.
Delbert, Simon, Tallow, 1724 Arch st. L.
Derbyshire, A. J., 109 N. Water st. C.
Desmond, Wm. C., Costumer, 917 Race st. C.
Deutz, A. Cornelius, Jeweler, 96 N. 5th st. L.
Devlin, Thos., Iron Foundry, 9th and Jefferson sts. C.
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Dialogue, John H., Steam Ship Builder, Broadway and Pine st., Camden, N. J. 2nd.
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Dillon, Eli, Plasterer, Ridge av. and Green st. L.
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Doll, George, Turner, 10 N. 6th st. C.
Donohugh, Wm. J., Clerk, 723 Arch st. C.
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Dougherty, Jas., Moulder, 13th & Buttonwood sts. L.
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Douglas, E. V., Machinist, Germantown. C.
Downing, Richd. H., Iron, 1613 Race st. L.
Doyle, James, Builder, 911 Filbert st. C.
Draper, Edmund, Math., Inst., Maker, 226 Pear st. L.

Draper, Prof., John W. L.
Drayton, Wm. Heyward, Lawyer, 704 Walnut st. L.
Dreer, Ferdinand J., 1520 Spruce st. L.
Drown, Wm. A., Umbrellas, 246 Market st. C.
Drown, Jr., W. A., Umbrellas, 246 Market st. C.
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Dubois, W. L., Treasurer, 421 Chestnut st. C.
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Ducomb, John F., Book Binder, 27 S. 6th st. L.
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Eavenson, A. T., M'f'r, 2013 Vine st C
Eccles, J., Machinist, 2423 Lombard st. 2d.
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Ehlers, P., Engineer, 101 S. Front st. C.
Eisenbrey, E. T., Merchant, Dock & Pear sts. C.
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Elkinton, H. H., Engineer, 477 N. 4th st. C.
Elkinton, Jos. S., Manuf'r, 9 N. Front st. L.
Elkinton, L. M., Soap, 116 Margaretta st. C.
Elliott, James, 39 N. 7th st. C.
Elliott, John F., Manuf'r, Masonville, N. J. C.
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Emery, T. S., Iron Manuf'r, 334 Walnut st. C.
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Ewing, Daniel S., Merchant, 1127 Chestnut st C
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Fell, John R., 1406 Walnut st 1st
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Ferguson, Jos. C., Engineer, 522 Walnut st. 1st.
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Fisher, Thos. R., Manufacturer, Germantown. L.
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Fodell, Wm. P., Secretary, 58 Laurel st. C.
Forsyth, Joseph W., Plumber, 25 S. 7th st. L.
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Foster, Joshua, Teacher, N. W. Broad and Pine sts. C.
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Fowler, John, Mechanical Engineer, 37 Laurel st. C.
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Fraiser, James, Carpenter, 331 Pine st. C.
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Frederick, Montgomery L., Engraver, 153 S. 4th st. L.
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Freedley, W. G., Marble, 210 S. 24th st. D.
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French, Louis H. 1st.

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Fritz, Peter, Marble Mason, 616 Race st. L.
Frost, E. J., Manufacturer, 223½ S. 5th st. C.
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Fry, Jacob W., 908 N. 5th st. L.
Fry, Paul Jones, Insurance Broker, 1734 Mt. Vernon st. C.
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Furbush, M. A., Machinist, 212 Market st C.
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Furness, Howard H. L.

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Gardiner, Wm. D., Carriage Builder, 214 S. 5th st. 2d.
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Garrett, William C., 224 S. Front st. C.
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Geddes, W. F. Jr., Printer, 724 Chestnut st. C.
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Godey, L. A., Publisher, 6th and Chestnut sts. L.
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Gravenstine, J., Refrigerators, Ridge av. ab. 12th st. C.
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Greble, Edwin Jr., 1708 Chestnut st. 1st.
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Gropengiesser, L. C., Watchmaker, 814 Walnut st. C.
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Grote, G. A., Machinist, 3005 Chestnut st. C.
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Gutekunst, F., Photographer, 712 Arch st. L.

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Hall, John, Engineer, 1203 S 13th st C
Hall, John, Machinist, 2415 Jefferson st. C.
Hall, Mary R., Cashier, P. O. 2820 C.
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Hand, T. C. Jr., 1506 Arch st. C.
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Harper, T. B., Metal Bins, 2035 Wallace st. C.
Harper, W. Lumber Dealer, 2035 Wallace st. C.
Harper, Jr. W. Brick Layer, 623 Federal, st. L.
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Harris, T. A., Dyer, 1303 Hancock st C
Harris, Geo. S., Printer, 4th and Vine sts. L.
Harris, William, Druggist, 1 Arch st. L.
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Harrison, G. L. Jr., M'f'r, 1704 Locust st. 2d.
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Harrison, W. H., Machinist, 1708 Barker st. C.
Harrison, W. W., Sugar Refiner, Almond ab. Delaware av. C
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Heller, Max, M.D., 709 Brown st. C.
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Henszey, W. H., Draughtsman, 1312 Filbert st. C.
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Henzey, Jos. G., Mining, 110 S. 4th st. C.
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Hess, J. M., Machinist, 1345 Buttonwood st. C.
Hessen J., Machinist, 1660 Hamilton st. 2d.
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Hewett, J., Merchant, 409 Market st. L.
Hewston, G., Physician, 766 Vine st. L
Heyl, H. R., Manufacturer, 440 N. 12th st C
Heysinger, I. W., Physician, 1433 Girard av C
Hibbs, J. M., M'f'r, 1330 Buttonwood st. C.
Hibbs, J. S , Founder, 305 E. Girard av C
Hickson, C. O., Machinist, 978 N. 6th st C
Hiester, A S., Dealer, 12th st Market C
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Hiltebrand, E., Librarian, 15 S. 7th st C
Hinchman, J. H., Clerk, 606 Samson st C
Hipple, W. Hall, 940 Race st L
Hitchcock, H. S., Teacher, Broad & Pine sts C
Hobbs, C. M., Signal officer, 133 So. 2d st. C.
Hoehle, C., Draughtsman, 1365 Beach st. C.
Hoffman, Geo. E., Engineer, 259 S. 17th st. C.
Hoffman, H. J., Manufacturer, 111 S. 20th st. C.
Hoffman, J. W., C. and M. E. 259 S. 17th st. C.
Hofstetter, Aug., Binder, 19 N 10th st C
Hofstetter, Geo., M'f'r, 111 S 8th st C
Hohenadel, John Jr., 29th and Penna. av. 2d.
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Holman, Lydia, 431 Arch st, C.
Holmes, Seth C., 110 Market st. L.
Hollis, P. C., Accountant, 407 Library st. C.
Hollinshead, B. M., 537 N. 7th st. L.
Hollowell, D. S., Bookkeeper, Frankford C
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Hoopes, D. J., Jeweler, 724 Chestnut st. C.
Hoover, H., N. Constructor, 323 Wharton st. L.
Hoover, J. Eves, Jr., Ink Mfr., 416 Race st. C.
Hoover, Jos. E., Ink Manuf., 416 Race st C
Hope, Thos., Machinist, 2011 Cedar st. C.
Hopper, Thos. C., Gas Maker, N. W. 22d & Arch sts. C.
Horne, C. H., Merchant, 358 Merchant st. L.
Horne, C., Undertaker, 23 N. 11th st. C.
Horstmann, F. O., M'f'r, 5th & Cherry sts. L.
Hoskins, John, 720 Wood st. 2d.
Hoskins, Raper, Fancy Store, 913 Arch st. C.
Houghton, H., Agent, 111 Arch st. C.
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Houston, J. F., Civil Engineer, Columbia, Pa. L.
Howard, C. W., Inventor, 1505 Ridge av. C.
Howard, G. C., Machinist, 13 S. 18th st. L.
Howard, W. H., Media, Del. co., Pa. L.
Howe, H. M., Physician, 1606 Locust st 1st
Howell, G., Paper Hangings, 900 Chestnut st. C.
Howell, W., Paper Manuf., 12 S. 6th st. L.
Howell, Z. C., Paper Hangings, 12 S. 6th st. C.
Howson, H., Patent Attorney, 119 S. 4th st. 1st.
Hudson, Thomas, 1022 Wallace st. C.
Huff, J. W., Printer, 705 Jayne st. C.
Hughes, W. W., Iron Works, 139 N. Front st. C.
Hullinger, J. W., Teacher, Beverly, N. J. C
Humphrey, H. C., Chemist, 113 Walnut st. C.
Hunt, J. G., Physician, 123 N. 10th st C
Hunt, Jos., Mining Eng., Catasauqua, Pa. C.
Hunter, J., Calico Printer, 55th & Paschall. L.
Hunter, J. C., Plumber, 1150 S. Broad st. L
Hunter, Jos. L., Engineer, 126 Walnut st C
Hunter, H., Gas Fitter, 55th and Paschal st L
Hutchinson, J., California. L.
Hutchinson, Israel P 1st

Hutchinson, Robt, Notary, 1416 Fairmount av L
Hutton, Addison, Architect, 215 S. 5th st C
Hutton, Finley, Builder, 120 N 13th st C

Iddings, Frank H., Clerk, 421 N. 7th st C
Ingersol, Harry, U. S. Navy L
Ingham, W. A., President, 320 Walnut st C
Irwin, J. H., Morton, Del. co., Pa C
Ivens, A. B., Teacher, Friend's Central Sch'l L

Jacoby, G. W., Marble Dealer, 2025 Market st C
Jack, Louis, Dentist, 1533 Locust st C
Jackson, B. F., Printer, 404 Library st C
Jackson, G. W., Printer, 404 Library st C
Jackson, S., Pyrotechnist, 1414 Ellsworth st C
James, Bushrod W., Physician, 18th and Green sts C.
James, Samuel, Machinist, 519 N. 43d st C
Janney, B. S. Jr., Grocer, 123 Market st C
Jayne, E. C., Druggist, 42 Chestnut st L
Jeanes, J. T., Merchant, 1023 Arch st L
Jeffreys, Wm., Blacksmith, Liber st L
Jenks, B. H., Machine Maker, 732 Market st L
Jessup, Alfred D, 1426 Walnut st 1st & L.
Jewell, Leonard, Merchant, 1425 Chestnut st. L.
Johnson, Chas. Eneu, Ink Manf., 500 S. 10th st. L.
Johnson E. H. Mach'st, 23d & Wash'ton av C
Johnson, Geo. L., 5th and Library sts. L.
Johnson, Geo. R., Tinsmith, 7th and Sansom sts. L.
Johnson, Orlando, Machinist, 1345 Buttonwood st. C.
Johnson, Robt. P., Carpenter, 509 Locust st. C.
Jones, Alfred, Ross st., Germantown. L.
Jones, Alfred, Physician, 254 S. 12th st. C.
Jones, Alonzo L, Steam-fitter, 51 S 4th st. C.
Jones, George, Teacher, 186 N. Front st. L.
Jones, Geo. W., Clerk, 2044 N. 12th st. L.
Jones, J. P., Merchant, 1608 Market st. 1st & L.
Jones, J. Howell, 1834 Filbert st. 2d.
Jones, Nathan F., C. E., Norristown, Pa. L.
Jones, Owen, Iron Founder, 16th and Market sts. L.
Jones, Owen, Merchant, 200 Market st. L.
Jones, Warner C., Hardware, 2809 Girard av. L.
Jones, Washing on, Steam Engineer, Richmond and Ball sts. L.
Jordan, John, Jr., Merchant, 121 N. 3d st. L.
Jung, Jacob, M.E., Centennial Grounds. C.
Justi, Henry D., Dentist, 516 Arch st. C.
Justice, Alfred B., Hardware, 14 N. 5th st. 2d.
Justice, Howard R., Salesman, 14 N. 5th st. C.
Justice, Lemuel B., Machinist, 649 N, 7th. C.

Kain, Henry C., Teacher, 524 Cooper st., Camden, N. J. C.
Keefer, Wm. W., 1416 Chestnut st. In trust for Wm. B. Keefer. 1st.
Keeley, Jerome, Tin Plate, 432 Market st 2d
Kelly, John F., Gentleman, 524 Walnut st C
Kelley, Henry H., Druggist, 1706 Green st L
Kelly, Wm. D., Attorney-at-law, Myrtle and N. 41st sts L
Kelly, Wm. S, Wood Machine Manf., 2019 Vine st C
Kendall, E. O, Teacher Univ Penna C
Kennedy, Elias D., Broker, 308 Walnut st 2d
Kennedy, John M., 1423 Arch st 1st
Kern, John. Draughtsman, 1015 Race st L
Kern, Wm. E., Drawing Teacher, 1015 Race st C
Kerr, David B., Supt., 3528 Fairview st. C.
Kerr, James K., Machinist, 1218 Chestnut st C
Kerr, Wm., Engineer, 1208 S. 15th st C
Kershaw, John G., Lawyer, 119 S. 4th st 2d
Ketcham, Hulings C., Carpenter, 811 Fairmount av C
Ketterlinus, E., Printer, N. W. 4th and Arch sts. L
Kichner, J. T., Merchant, 812 E York st C
Kile, John, Pattern Maker, 808 N 17th st L
Kildare, Wm. P., Printer, 736 Sansom st. C.
Kilgore, John, House Carpenter, Wood and Juliana sts L
Killie, John T., 1822 Green st 1st
King, Thomas, Carpenter st L
King, Wm. F., Draughtsman, 706 Locust st C
King, Wm. T., Clerk, Camden, N J L
Kinsey, John L., Clerk, 3d and Vine sts C
Kinsey, Wm., Jr, Morocco Manf., 3d & Vine. C.
Kirk, J. J., Clerk, 1617 N. 10th st. 1st.
Kirk, Geo. H, 1528 Brown st 1st
Kirkbride, Thos. S, Physician, 44th and Haverford rd C
Kirkhuff, J. D, Teacher, Broad and Pine sts C
Kirkpatrick, Alex. E, Hide Dealer, 3d and Vine sts C
Kirkpatrick, Edwin, Merchant, 3d and Vine sts C
Kirkpatrick, Frank L, Watchmaker, 1416 Chestnut st C
Kirkpatrick, Jas. A, Asst. Supt. Girard Estate, 2014 Vine st L
Klapp, Jos, Physician, 622 Spruce st L
Knapp, G. S., Inventor 269 Girard av. C.
Kneass, Napoleon B., Saddle Manf., 2121 Columbia av. L.
Kneass, Strickland, Civil Eng., 233 S. 4th st. C.
Knight, Daniel R. L.
Knight, E. C., Merchant, 1605 Chestnut st. L.
Knight, Hartley, Merchant, 1222 Chestnut st. 2d
Knight, Jacob B., Eng., 15 S. 7th st. 1st.
Knight, W. A., Hardware, 514 Commerce st C
Knorr, J. Francis. L.
Knowlton, John L., Machinist, 419 Walnut st. C.
Koenig, Geo. A., Prof. Chemistry, 3603 Atlanta st. C.
Koons, Chas. B., Heaters, 1128 Market st. C.
Kramer, Henry, 1345 Palmer st. 2d.
Krider, Peter L., Silversmith, 118 Cherry st C
Krumbhaar, Alex., File Mfg., 1601 Spring Garden st. C.
Krumbhaar, Wm. T., Iron Founder, 115 S. 21st st. C.
Kuhn, Chas., Broker, 1712 Spruce st. L.
Kuhn, C. Hartman, Broker, 1712 Spruce st. L.
Kuhn, Hartman Jr., 240 Walnut st. L.
Kutz, Geo. F., M. Engineer, 1128 Wallace st. C.

Lagomarsino, A., Mfr., 8th and Christian st. C.
Laing, Henry M., Shoe Findings, 335 N. 11th st. L.
Lamasure, Edwin, Accountant, 134 S. 2d st. C
Lambdin, Jas. R., Artist, 1221 Chestnut st. L.
Lambert, John, Attorney, 152 S. 4th st L
Lamborne, Robt., President, S. E. cor. 5th and Library st 2d

Lancaster, Wm. H., Carpets, 756 S. 2d st C
Lang, Geo. S, Engraver, Media, Del. Co., Pa. C
Lane, Benj. H., Clerk, 9th and Parrish sts 2d
Langford, John, Physician, 5th and Christian sts C
Large, Daniel, Engineer, Poplar ab. 2d L
Laroche, R., Physician 242 Walnut st L
Latham, Richard, Engineer, 1708 Chestnut st C
Latimer, Thos., 5th and Library sts C
Lawrie, C. W., Machinist, S. E. cor. 10th and Locust sts C
Lea, Henry C., Pub., 706 Sansom st L
Lea, Isaac, Bookseller, 1622 Locust st L
Lea, M. Carey, Attorney, 426 Walnut st L
Leavitt, E. D., M.E. 2d
Le Boutillier, Roberts, Germantown L
Le Conte, John, Physician, 321 Locust st L
Lee, Geo. Burtis, 533 N. 6th st C
Lee, Geo. F., Builder, 533 N. 6th st L
Lee Thos., Draughtsman, 233 S. 4th st C
Lee, Thos D., Grate Maker, 329 S. Broad st L
Leeds, Albert R., Teacher, Hoboken, N. J. 2d
Leeds, B. Franklin, 528 Walnut st 2d
Leeds, Josiah W., Real Estate, 528 Walnut st 2d
Leffman, Henry, M.D., 1081 Frankford av. C.
Lejee, Wm. R., Broker, 1801 Walnut st L
Lennig, Chas., Wools, 112 S Front st L
Lenthall, John, C. E., Washington, D. C. L
Leguin, G. E., Merchant, 208 West st., N. Y. C
Leroy, A. C., Draughtsman, 1600 Hamilton st C
Lesley, Jos., Secretary, 233 S 4th st C
Lesley, J. P., Geologist, 104 S 5th st C
Leslie, Wm. O., Mfg., 615 Walnut st C
Le Van, W. B., Engineer, 3607 Baring st L
Lever, Jas. S., Bookbinder, 46 N 7th st C
Levick, R. H., Merchant, 721 Chestnut st C
Lewis, Enoch, Purchasing Agt., 233 S 4th st C
Lewis, E. J., Physician, 126 Chestnut st. C.
Lewis, Ed. M., President, 427 Chestnut st. C.
Lewis, Geo. F., Plate Printer, 33 S. 3d st. L.
Lewis, Henry Carvill, East Washington Lane, Germantown. L.
Lewis, Milfred, Mechanic, 23d & Powel'n av. 2d.
Lewis, S. T., Machinist, 1931 Callowhill st. C
Lewis, W. J., C.E., San Francisco, Cal L
Lewis, Wilfred, Mechanic, 33d & Powelton 2d
Lex, J. H., Secretary, 34 N. 5th st L
Lightfool, Jesse, Lawyer, 4931 Germant'n av C
Lilly, W., Coal & Iron, 303 Walnut st. C
Lindenthal, G., C.E., Elm st & Belmont av C
Lindsay, R., Publisher, 528 Franklin st L
Linville, J. Hays, Engineer and Architect, 218 South Fourth st C
Lipman, H. L., Stationer, 32 S. 4th st C
Lippincott, C., Manufacturer, 916 Filbert st C
Lippincott, Hilles, Bookkeeper, 920 Franklin st C
Lippincott, J. B., Publisher, 717 Market st 1st & L
Lippincott, Josh., Jr., Clothier, 538 N. 6th st C
Little, Thomas, Builder, 343 S. 12th st C
Littleton, Wm. E., 514 Walnut st 1st
Livesey, John, 1123 Arch st 1st & L.
Lloyd, Mrs. F., Teacher 1615 Chestnut st C
Lloyd, Malcolm, Petroleum, 307 Walnut st C
Loftis, P. S., Jeweler, 61 N. 8th st C
Loiseau, E. F., M'f'r, Port Richmond. C
London, W. E., Machinist, 22d abv. Arch st C
Longacre, Matthias R., Engraver and Lithographer, 7th & Market sts C
Longstreth, Ed, Machinist, 500 N Broad st C
Longstreth, J. Cooke, Lawyer 125 S 7th st C
Loos, A., Teacher, 1934 Mervine st C
Loper, Capt. R. F., 19 Pine st L
Loughlin, W., Jr., Lawyer, 632 Christian st 2d
Lovegrove, T. J., Boiler Insp., 119 S 4th st C
Lovering, Jos. S., 119 S 4th st L
Luder, Thos. L. L
Lukens, Amos, Blacksmith, Plymouth Meeting P. O., Montgomery co. Pa. L.
Lukens, David L., Clerk, 1600 Hamilton st. 2d
Lukens, Jas. T., Dry Goods, 513 Marshall st L
Lukens, Michael, Bookkeeper, 1521 N 23d st C
Lush, John F., Carpenter, 518 Federal st C
Luthy, Otto, Chemist, 451 N 4th st C
Lyman, Benjamin S., Mining Engineer, 135 S. 5th st C
Lynn, John W., 426 S Delaware av 1st
Lyon, C. Wesley, Chemist, 215 S. Front st C

Maas, Chas. E., Engraver, 1619 Norris st L
Maas, Wm. A., Printer, 1337 Mt. Vernon st L
MacCallum, Hugh, Machinist, Germantown. C
MacDonald, Charles, C.E. 80 Broadway, N.Y. C
Macdowell, William H., Engraver, 1028 Chestnut st. C
MacHarg, E., Teacher, S.W. 16th & Spruce C
MacPherson, Angus N., Bordentown, N J
Madeira, J. F., Manufacturer, 1615 N 9th st C
Magargee, Charles, Paper Dealer, 6th & Jayne sts L
Magee, Frank H., 1219 Arch st 1st
Magee, James, Saddler, 18 Minor st L
Magee, James R., 1219 Arch st 1st
Magee, Michael, Saddler, 8 Decatur st L
Maloy, Chas. W., 1515 S. 5th st. 2d.
Marcy, L. J., Optician, 1340 Chestnut st C
Marembeck, G. W., Heaters and Ranges, 2145 N. 7th st C
Maris, John M., Chemist, 711 Market st C
Marriner, S. R., Carpenter and Builder, 1318 N. 19th st C
Marsh, Benj. V., Merchant, 309 Market st C
Marshall, Samuel R., Machinist, 923 N. Broad st C
Marshall, W. M., Manuf., 1529 Green st C
Marter, J. B., Sewing Mach., 730 Chestnut st C
Martin, Jas., Jr., Machinist, 1 Coombs Alley L
Martin, Wm. N., 912 Arch st C
Martin, W. A. K., Scholar, 856 N. Broad st C
Martindale, J C, Cashier, 322 Penn st, Camden, N J C
Martindell, G. L., Milliner, 10 N. 8th st 2d
Marx, Geo. W., Dyer, 840 N. 3d st C
Mason, Jas. S., Manuf., 140 N. Front st 1st
Mason, Saml., 220 S. 4th st. L.
Massey, W., Brewer, 10th and Filbert sts 1st
Matlack, J. R., Physician, Race & Chester sts L
Matlack, J. David 2d
Maule, E., Lumber Dealer, 2500 South st C
Mecke, Fred. T., Manuf., 124 Church st C
Megargee, S. J., Merchant, 20 S. 6th st C
Megargee, Theo., Paper Manuf., 20 S. 6th st C
Meigs, H. V., Machinist, 973 N 6th st C
Meigs, J. A., Physician, Broad and Lombard sts L
Melchor, Martin V. B 1st
Mellor, Alfred, Chemist, 218 N. 22d st C
Mellor, Thos., Merchant, Chelton Hills, Pa. L
Menamin, R. S., Publisher, 515 Minor st C

Merklee, Chas. K., Manuf., 1320 Wallace st C
Merrick, J. Vaughan, Roxborough, Phila. 1st and L
Merrick, Sam'l G., 3926 Walnut st. 2d
Merrick, Wm. H., Machinist, 230 S 3d 1st & L
Messchert, M. H,, Lawyer, 1528 Arch st L
Meyer, Conrad, Pianos, 722 Arch st C
Meyer, C. Eugene, Pianos, 722 Arch st C
Michener, E. P., Civil Engineer, 13th and Sp'ng Garden sts C
Mickley, Jos. J., Piano Manuf., 1329 S. 15th st C
Middleton, C., Iron, 2d and Willow sts L
Middleton, C. W., Iron, 945 Ridge ave 2d
Middleton, H. W., Iron, 945 Ridge ave 2d
Middleton, John W., Iron, 616 N. 5th st. C
Middleton, Nathan L
Middleton, Samuel, Mechanical Engineer, Nicetown, Pa C
Miles, Fred. B., Engineer, 24th and Wood sts C
Miller, Adolph W., Physician, 860 N. 5th st C
Miller, D. K., Lock Manuf., 712 Cherry st C
Miller, Edward, Civil Engineer, 246 Spruce st L
Miller, E. W., Bookbinder, 1702 Vine st L
Miller, Geo. S., Bookkeeper, 505 Market st C
Miller, Jas. H., Brass Founder, 1028 Spring Garden st C
Miller, W. H., Draughtsman, 1523 Poplar st C
Miller, Jos. S., Manuf., 1210 Ridge ave C
Mills, Chas. K., Physician, 1502 Columbia av C
Mills, Jos. H., Silver Plater, 508 Poplar st C
Milne, Caleb J., Manuf., 306 Walnut st L
Milne, F. F., 306 Walnut st C
Milsted, Wm. M., Clerk, Arch and 22d st C
Mingus, P. P., Blacksmith, Cherry and Juniper sts L
Minich, A. R., Physician, 2228 N. Front st C
Minister, Jos. B., Color Mixing, 18th and Washington ave C
Mintzer, Geo. E., 752 N. 20th st C
Missemer, J. H., Salesman, 426 Market st C
Mitchell, J B, 715 Market st 1st
Mitchell, Jos E, Merchant, 310 York ave C
Mitchell, J Henry, Machinist, 604 Beach st C
Mitchell, J Howard, Merchant, 14 N 5th st C
Mitchell, Wm A, Merchant, 224 Federal st, Camden, N J L
Moody, Edward F, Camden, N J L
Moore, B H, Paper Manuf, 28 N 6th st 1st & L
Moore, Francis H, 107 N Water st 2d
Moore, G E, Ph D, Chemist, 4025 Sansom st C
Moore, Geo R, Rev, 1820 Cayuga st C
Moore, Henry D. 1st and L.
Moore, Wm H, Undertaker, 1610 Arch st L
Moore, Wm J, Carpenter, 1719 S Rittenhouse st L
Moorehouse, R O, Machinist, 13th and Buttonwood st 2d
Morgan, Alex. H, Engineer, 1534 Wallace st C
Morgan, Chas. W, Engineer, Frankford C
Morgan, Thos. A, 94 S. Front st L
Morrell, D. J, 218 S. 4th st 1st
Morison, Benj, Pat'nt Solicitor, 228½ Walnut st C
Morrill, Daniel J 1st and L
Morris, Chas. M, Merchant, 619 Walnut st. C
Morris, Henry 207 Spruce st L
Morris, Henry G, Iron Manf., 5th and Washington av L
Morris, Israel, 1608 Market st 1st
Morris, Israel W, 238 S 3d st C
Morris, Stephen, Iron Founder, 209 S 3d st L
Morris, Walter, Phila. Nat. Bank C
Morris, Wistar, 3d and Walnut sts L
Morris, J. Cheston, Physician, 1514 Spruce st C
Morrison, Alex., Manuf., 3739 Spruce st C
Mortimer, Chas, Copper Plate Printer, 297 Vine st L
Morton, Prof. Henry, President, Hoboken, N J L
Morton, Rev. Henry J, 909 Clinton st 1st
Moss, Theodore F, Mining Engineer L
Mott, G. S, Telegrapher, 627 Spruce st C
Muckle, Alex, Chemist, 1321 N 19th st C
Mucklé, M. R., General Manager, 600 Chestnut st C
Muringer, Julius, Chemist, 626 N. 10th st C
Murphy, Howard, C.E. C
Murphy, Wm. C, Painter, 181 S 2d st L
Murray, Chas W, Stereotyper, S W 7th and Market sts L
Murray, Matthew, Machinist, 109 Filbert st L
Murray, Peter, Founder, 2214 Brandywine st C
Murray, Sam'l A., Jr, 1711 Coates st C
Murta, John P, Accountant, 249 S 8th st L
Myer, Isaac, Attorney, 152 S 4th st C
Myers, Wm. H, 631 Walnut st C
McAllister, John L
McAllister, W. Mitchell, Optician, 728 Chestnut st L
McAlpine, Daniel, Machinist, 1422 N 18th st C
McArthur, John, 408 S. Broad st L
McArthur, John, Jr, Architect, 1334 Chestnut st C
McBride, Thomas, Hydraulic Engineer, 243 S 6th st C
McCall, Peter, Attorney-at-Law, 224 S 4th st C
McCambridge, Richard, Brass Founder, 527 Cherry st. C
McCambridge S, Saddler, 523 Cherry st C
McCaffrey, Hugh, File M'f'r, 1736 N 4th st C
McCaffrey, John, File M'f'r, 1615 N 4th st C
McCarter, Wm., Painter, 1515 S 6th st C
McClure, John, Builder, 21 S 16th st L
McCollin, James G, 1600 Hamilton st 2d
McCollom, T. C, C.E, 1811 Lee st C
McConn, John, Inventor, 920 Walnut st C
McConn, Wm. S, Steam Heaters, 920 Walnut st C
McConnell, Alex, Tar and Pitch, 2929 Gray's Ferry rd C
McCorkle, D. C. W, Bookkeeper, 1117 Girard av C
McCormick, A. A, Engraver, 1006 Chestnut st C
McCowan, John L
McCowen, Wm. A, Machinist, 1040 Stocker st C
McCurdy, John R, Manufacturer, 116 Arch st L
McElroy, Jos. B., M'f'r, 2426 Lombard st C
McFadden, Wm. H, C.E, 13th and Spring Garden sts 2d
McGinn, John J, Engineer, 2255 Palethorp st C
McIlvaine, A. Robinson, Drug and Spice Mill, 15th and Hamilton sts L
McInnes, J T, Lime Merchant, 9th bel Master C
McIlvaine, William, S E 8th and Walnut sts L
McIntyre, C, House Carpenter, 106 S Front st L
McKean, W. V, Manager Public Ledger, 6th and Chestnut sts C
McKinley, Benj. B, Teacher, 425 S 16th st L
McKnight, Wm, Shoe Manf. 32 S. 4th st C
McMinn, H. S, C.E, Pennington, N J 2d
McMurray, Andrew S, Physician, 325 Pine st L

Nagle, George F, Paper Hanging, 1210 Chestnut st C
Napheys. George H, Physician, 115 S 7th st C
Naylor, Jacob, Iron Founder, Front and Girard av L
Neal, Wm. 536 N 7th st L
Neall, G. M, Yarns, 110 N 3d st C
Negus, J. Engle, Merchant L
Nelms, Henry, Gold Beater, 46 N 7th st L
Newmann, Joseph, Manufacturer, 919 Race st 2d.
Newman, R. M., Com. Merchant, S S Front C
Nevil, Wm. H, Morocco Manf. 144 Margaretta st C
Newbold, J. S., Merchant, 719 Pine st L
Newbold, T. M., Druggist, 105 S. 41st st 2d
Newcomer, U. S., Bingham House. C
Newell, H., Chief Eng., Navy Yard. C
Newell, W. H., Machinist, 816 Spr. Garden st C
Newhall, George, 528 Spruce st C
Newhall, G. M., Sugar Refiner, 225 Church st C
Newlin, John S. L
Nichol, J. H., Leveller, 932 N. 2d st C.
Nicholls, E., Com. Traveller, 1937 Camac st C
Nicholson, C. L., Lumber, N. W. 7th and Carpenter sts L
Nicholson, Jos., 808 N. 16th st C
Nicholson, Richard L L
Nieland, J., Machinist, 410 N. 10th st C
Norris, I., Jr. Physician, 1424 Walnut st C
Norris, Richard. 1st.
Norris, Samuel. 1st
Norris, Thad., Jr. Engineer, 221 S. 18 st C
North, G. W., 3718 Locust st C
Nugent, E., Druggist, 18 N. Front st C
Nystrom, J. W., C. E., 1005 Spruce st L

Oat, G. R, Coppersmith, 1307 Arch st C
Oat, Jos., Coppersmith, 232 Quarry st C
Odenatt, M. H., Millwright, 1527 Savery st C
O'Driscoll, C. F., Stereotype Founder. L
Oesterle, P., Draughtsman, 232 Quarry st C
Ogram, Thomas, 1521 Ogden st 2d
O'Hara, J. H., Tailor, 29 N. 6th st C
Olier, T. K., Sewing Machines, 1106 Chestnut st C
Oliver, G. L., 1412 Arch st 1st
Olsen, T., Draughtsman, 1914 N. 11th st C
O'Neil, J., M.E., 699 Broadway N. Y. C
O'Neill, G., Chemist, 1909 Ellsworth st C
Opdyke, S. B. Jr., C. E., 1412 N. 15th st C
Ord, J., Architect, 215 S. 5th st C
Orr, H., Printer, 202 Chestnut st L
Orton, L. O., Machinist, 22d ab Arch st C
Orum, M. L., Machinist, 448 N. 12th st C
Ott, G. F., Draughtsman, 213 Buttonwood st C
Ourt, L., Black and White Smith, Riverton N. J. C
Outerbridge, Alex. E. Jr., Assay Laboratory, U. S. Mint. C

Paddock, F. L., C.E. 4827 Haverford st C
Palmer, B. F., Surgeon Artist, 1609 Chestnut st L
Pancoast, A., Chemist, 1030 Chestnut st C
Pancoast, C. S., Attorney, 416 Walnut st C
Pancoast, H. B., Clerk, 227 Pear st C
Pardee, A., Coal, 303 Walnut st 1st
Pardee, A. Jr., Iron, 303 Walnut st 1st
Pardee, Calvin, Coal, Hazleton, Pa 1st
Parke, J. P., Trenton, N. J. C
Parker, G, House Carpenter, Berkley, Gloucester co N. J. L
Parker, J., 86 Wood st L
Parker, W. H., Teacher, School 8th and Fitzwater sts C
Parks, G. C., Bricklayer, 1010 Brown st C
Parkinson, R. B. L.
Parrish, D., Druggist, 1017 Cherry st L
Parrish, R. A. Jr., Counsellor at Law, 727 Walnut st C
Parry, C. T. Machinist, 500 N Broad st L
Pattrick, J., Telegrapher, 38 S. 4th st C
Paterson, W. F., Chf. Eng. Doylestown, Pa. C
Patterson, A. H., Clerk, 419 N. 6th st 2d
Patton, T. R., Merchant, S. E. 13th and Locust sts 1st
Peacock, H. H., Fancy Morocco Cases, 610 Chestnut st C
Peele, E., Sewing Machines, 1911 N. 12th st C
Peifer, G. F., Engineer, 720 Aramingo st C
Peltz, P. G., Eng. U. S. N., Schuylkill Falls. L
Pennell, L., Bookkeeper, 1 Walnut st 2d
Pennock, J. S., Plumber, 805 Franklin st C
Pennypacker, M., Machinist, 1122 Green st C
Perkes, C., Brass Founder, 627 Arch st C
Perkins, A. R., Merchant, 102 S. 9th st L
Perot, T. M., Druggist, 1810 Pine st L
Perry, W. G. Bookseller, 728 Arch st L
Peters, C. J., Hat Manufacturer, S. E. 5th and Market st C
Peterson, R. E. Jr., 1927 Spring Garden st 2d
Peterson, W., Chemical Works, 1 Arch st C
Petraus, V., Chemist, 231 S. Front st C
Pettit, H., C.E. 1509 Walnut st C
Pettitr, W., 2131 Mt. Vernon st L
Phelps, Ira M., Physician, 1612 Filbert st C
Philips, W. J., S. W. 5th and Chestnut st C
Phillips, Chas. C., 934 N. 5th st 1st
Phillips, Cyrus, 617 Arch st C
Phillips, F. C., Chemist, 306 S 13th st C
Phillips, G. Brinton, Chemist, 1605 Spring Garden st C
Phillips, H. C., Photographer, 1206 Chestnut st C
Piers, Louis J., Accountant, 1201 Green st L
Pierce, Parker D., Druggist, N. E. cor. 2d and Callowhill sts C
Pile, Wm. H., Printer, 422 Walnut st C
Pile, Wm. H., 1401 Locust st C
Pistor, Philip, Draughtsman, 2318 St Alban's Place. C
Platt, Franklin, Geologist, 139 S 5th st C
Pleasanton, Gen. A. J., 918 Spruce st 2d
Poole, Alfred D., Machinist, Wilmington, Del. C
Potsdamer, T. B., Lithographer, 321 Chestnut st C
Potter, Thos., Oil Cloth Mfr., 418 Arch st L
Potts, Albert, Iron Merchant, 238 N Front st. L
Pounds, Wm. H., Brass Worker, 15 N 7th st C
Powell, John M., 3613 Powelton ave 1st
Powell, Samuel W., Student, Easton, Pa. C.
Powers, Thos. H., Mfg. Chemist, 9th and Parrish sts L
Pratt, A. H., Advertising Agent, N. E. cor. 5th and Walnut st C
Pratt, Daniel R., Machinist, Worcester, Mass. L
Price, Chas. H., Cashier, 306 Walnut st 2d

Price, Jacob S., Carpenter, N. W. cor. 11th and Shippen sts L
Price, Joseph. L
Price, Samuel, Bricklayer, Pine bel. 12th st L
Price, Wm. S., Attorney at Law, 633 Walnut st C
Prince, John F., Marble, 2214 Chestnut st C
Prince, Sam. F., 2214 Chestnut st C
Prince, Sam'l F, Jr., M.E., 2214 Chestnut st
Prindle. F. C., C.E., 10 S. Del ave C
Pugh, Chas. E., 3003 Market st C
Pugh, J. H., Silver Plater, 1545 N 12th st C
Purves, A., Merchant, 17 South st L
Purves, Chas., 17 South st C
Pusey, Joshua, Mfr., 728 Buttonwood st C

Quig, Henry, Copper Plate Printer, 3762 Frankford rd L
Quimby, Benj. F., 224 S 5th st 2d

Ralph, Alex., Tobacconist, 115 Arch st C
Rand, B. H., M.D., 1615 Summer st L
Rand, Theo. D., Attorney, 17 S. 3d st L
Randolph, Evan, Merchant, 2002 Arch st L
Randolph, William, Clerk, Arch and 20th sts L
Rawle, Jas., Manufacturer, Bryn Mawr, Pa. C
Rea, W. Howell, Carpenter, 1803 Poplar st C
Reaney, Robt. L., Machinist, Frankford. L
Redfield, Jno. H., 216 W. Logan Square. 1st
Redfield, Robt. S., 1600 Callowhill st 1st
Reed, Henry H., Merchant, 1425 Chestnut st L
Reeves, Ellwood. L
Reeves, Sam. J., 414 Walnut st L
Reishard, Francis H., Notary Public, 424 Walnut st C
Reigner, H. F., Machinist, 1326 Mount Vernon st C
Reimer, Benj. F., Photographer, 617 N 2d st C
Remsen, Geo. C., Publisher, 624 Market st 1st
Rex, Abraham, 1035 Walnut st C
Reynolds, Jesse, Heaters and Ranges, 13th and Filbert sts C
Rhoades, J. H., Physician, 918 Sp. Garden st C
Rhoads, Joshua, Physician, Jacksonville, Ill L
Rhoads, Wm. G., Plumber, 1221 Market st C
Rice, D. E., M. D. C
Rice, George. 1st
Rice, Jas. D., 11 S 7th st 2d
Rice, John, 129 S 7th st 1st
Richards, G. W., Manufacturer, cor. Broad and Spruce sts L
Richards, John, Atlantic Works, 23d ab Arch 1st
Richards, L. H , Merchant, 228½ Walnut st C
Richards, P., Tack Maker, Germantown. C
Richards, T. W., Architect, 3332 Chestnut st C
Richards, S. R., Jr., Clerk, 1520 Race st C
Richards, Wm. J., Bookkeeper, 48 Wistar st., ab. 11th. L
Richardson, David, Physician, Almshouse. C
Richardson, George J., Fire Arms, 20th and Prime sts L
Ridgeway, Thos., 1705 Walnut st 1st
Riehle, Henry B., Scales, 9th and Master st C
Rimby, A., Manufacturer, 1615 N 9th st C
Ringwalt, J. L., Printer, 7th and Chestnut st C
Ritchie, C. D., Conveyancer, 508 Walnut st C
Riter, John A., Builder, 610 N 10th st L
Rittenhouse, Henry N., Mfg. Chemist, 218 N 22d st C

Robbins, John, Steel Manufacturer, 917 Shackamaxon st L
Roberts, Alfred R., C.E., 407 Walnut st C
Roberts, Caleb C., Adams Express Co., 1118 Arch st L
Roberts, Chas., Mfr., 410 Race st C
Roberts, C. J., Dry Goods, 912 Chestnut st 2d
Roberts, Edward, N.E. 11th & Spruce st L
Roberts, Elihu, Secretary, 307 Walnut st L
Roberts, George B., 1901 Spruce st 1st
Roberts, George Theo., 314½ Walnut st. 1st
Roberts, Percival, 265 S. 4th st. 1st
Roberts, Sol. W., C.E., 407 Walnut st 1st & L
Roberts, W. Milnor, C.E., Iselin, N. J. L
Robinson, C. W., Conveyancer, 812 Walnut st C
Robinson, E. W., 322 Walnut st L
Robinson, W. Massey, Brewer, 10th and Filbert sts. C
Rogers, Fairman, 202 W. Rit'house sq. 1st & L
Rogers, Fairman. In trust for Franklin A. Dick. 202 W. Rittenhouse sq 1st
Rogers, Prof. Rob't E., 1004 Walnut st. L
Rogers, T. M., Draughtsman, 716 Spruce st C
Rogers, W. D., Coach Maker, 1009 Chestnut st C
Rohrman, Jos. B., Clerk, 610 Cherry st C
Rolin, W. A., Carpet Dealer, 739 Market st L
Ronaldson, Chas. E., C.E., 4506 Pine st C
Rorer, John, Surg. Inst. Maker, 28 N 6th st L
Roscher, Ernest, Machinist, St. Louis, Mo. C
Rosengarten, G. D., Chemist, 1532 Chestnut st L
Rosengarten, H. B., Mfr., 325 S 17th st C
Rosengarten, M. G., 1815 Spruce st 1st
Rosengarten, Sam'l G., 1532 Chestnut st L
Rosenthal, John S., Spinner, 1713 N. 22d st C,
Rothermel, J. G.. Coal, 9th & Master sts 2d
Rowand, J. R., Physician, 1714 S 6th st L
Rue, Sam'l, Machinist, 523 Cherry st C
Ruschenburger, W. S. W., Medical Director, U. S. N., 1932 Chestnut st L
Rutherford, William H., Chief Eng. U. S. N., 1503 Spruce st L
Ryan, Thomas, Merchant, 40 S Wharves. L
Ryan, Thomas, Machinist, 1732 Callowhill st C

Sadtler, Sam'l P., Prof. of Chemistry, 38th and Darby road C
Safford, Henry W., 125 N. 21st st L
Sailer, Frank, Salesman, 9th & Parrish sts C
Sailor, Henry, Marble Cutter, 10th and Vine sts L
Salmon, C. H., Manufacturr, Oxford and Hancock sts C
Sample, H. C., Philos. Inst. Maker, 1924 Montrose st C
Sandgran, C. C., Plumber, 347 Wharton st 2d
Sandgran, G. N. Plumber, 347 Wharton st 2d
Sanford, J. L., Real Estate, San Francisco, Cal. C
Sanguinetti, P. A., Engineer, 3845 Warren st C
Sargent, Wm. D., Sup't, S.W. 7th & Chestnut C
Sartain, Harriet Judd, Physician, 210 Franklin st 2d
Sartain, Henry, Plate Printer, 728 Sansom st L
Sartain, John, Engraver, 728 Sansom st L
Sartain, Sam'l, Engraver, 210 Franklin st L
Sartain, William, Artist, 728 Sansom st L
Sauerbrey, C. W., Mining Engineer, 226 S 5th st C
Saul, Rev. James, D.D., 1630 Pine st. L
Savery, C. C., Mfr., Swanson & Christian sts C

Sawyer, Wm. H., Tel. Eng. A. D. Tel. Co., 3d and Dock sts C
Scattergood, Thos., Tanner and Currier, 278 N. Front st. L
Schafer, J. C., Stone Cutter. C
Schenkel, Geo. F., Machinist, 2437 N 9th st C
Schimmel, J. O., Fruit Preserver, 431 Master st C
Schiveley, G. S., Physician, 1515 Oxford st C
Schmidt, Edward, Machinist, 315 Vine st C
Schober, F., Mech. Eng., 478 N 5th st C
Schutte, L, Engineer, 222 Walnut st C
Schwarze, Aug., Merchant, 614 Arch st C
Schwenk, A. B., Student, 1344 Chestnut st C
Scott, Charles, 1128 Arch st 1st
Scott, Franklin, Gents' Furn'ing, 814 Chestnut C
Scott, G. W., Cooper, 1522 Moyamensing av 2d
Scott, Thomas A., President, 233 S 4th st 1st
Seal, Lewis, Merchant, 136 S 3 l st L
See, Richard C., Merchant, 1501 Spring Garden st. L
Seefeldt, W. F., Musical Inst. Mfr., 731 Race st C
Selden, Geo. S., Attorney, 1600 Master st C
Sellers, Coleman, Engineer, 1600 Hamilton st 2d
Sellers, Coleman, Jr, Machinist, 1600 Hamilton st 2d
Sellers, Jno., Upper Darby, Del. co, Pa. L
Sellers, Jno., Jr, Machinist, 1600 Hamilton st. L
Sellers, Sam'l, 614 Commerce st. 2d
Sellers, Wm., Engineer, 1600 Hamilton st L
Seltzer, J H, Superintendent, 2136 Market st C
Sewall, Basil, Agent, 713 Wood st 2d
Sexton, John W, Dry Goods Merchant, 112 S 3d st L
Seyber, Henry, 926 Walnut st L
Shain, Chas J, Math Inst Maker, 716 Chestnut st C
Sharpless, Henry G, Merchant, 187 Arch st L
Sharpless, J. T. Physician, 1227 Arch st L
Sharpless, N H, Lawyer, 28 N 7th st C
Sharpless, S J, 705 Walnut st 1st & L
Sharpless, Wm P. Merchant, 2513 Arch st L
Sharswood, Wm, Ph D, Con. Chemist, La Pierre House C
Shaw, Elias J, Draughtsman, 1321 N 22d st 2d
Shaw, John Eyre, Attorney, 110 S 4th st C
Shaw, Louis, Druggist, 838 N 9th st C
Shaw, Nathan S, Stone Cutter, 1309 Heath st C
Shaw, Thomas, Machinist, 913 Ridge ave C
Shea, Jas S, Machinist, 1533 Thompson st C
Sheaff, John F, Coal Dealer, 220 S 4th st C
Sheble, R, Cabinet Maker, Bensalem P O, Bucks co Pa L
Sheppard, Furman, Attorney, 717 Walnut st C
Shetzline, C W, Carpenter, 314 Dickinson st 2d
Shewell, Walter, Machinist, 1118 Coates st C
Shick, Wm H 1st
Shillingford, J T, Merchant, 125 S 4th st C
Shinn, Jas T, Druggist, Broad and Spruce sts L
Shinn, John, Machinist, 2022 N Front st 2d
Shoemaker, B H, Glass Warehouse, 205 N 4th st C
Shoemaker, G Y, Wagon Builder, 1237 Spring Garden st C
Shoemaker, J., Publisher, 717 Market st 2d
Shoffner, W N, Bookkeeper, 1911 Hamilton st C
Shrigley, John M., Machinist, 2029 Callowhill st 1st
Sidle, J W, Phil Inst Maker, 320 E Cumberland st C
Silver, J S, Coal Merchant, 97 S 8th st L
Simonin, Ch., T A, 20 S Delaware ave C
Simons, G. W., Jeweler, 611 Sansom st 2d
Simons, H, Jr, Wheelwright, 117 New Market st L
Simons, M P, Photographer, 1320 Chestnut st L
Simpson, Thos, Calico Printer, 1522 Arch st C
Sinclair, Thos, Lithographer, 508 North st C
Sinex, Thos L
Singer, E A, Teacher, 246 E Cumberland st 2d
Sloan, J, Farmer, Montgomery co, Pa L
Sloan, Samuel, Architect, 152 S 4th st C
Sloat, G B, Manufacturer, Kensington L
Slocomb, S A, Machinist, Farmer's Market C
Smedley, A M, Carpenter, 807 N 20th st C
Smedley, Sam'l L, Chief Engineer and Surveyor 224 S 5th st L
Smith, Albert H, Physician, 1419 Walnut st C
Smith, Benj, Accountant, 90 S 12th st L
Smith, B. R, Broker, 4717 Main street, Germantown C
Smith, Charles B 1st
Smith, Chas E, Engineer, 216 S 15th st L
Smith, Chas W L
Smith, DeWitt W, 135 N 3d st C
Smith, Edwin, Machinist, 1600 Hamilton st 2d
Smith, E M, Physician, 842 N 8th st L
Smith, Ephraim, Chemist, 1110 Pine st C
Smith, Geo F, Dry Goods, 133 S 11th st L
Smith, Geo W, 911 Clinton st L
Smith, H. W, 119 S Front st 2d
Smith, Isaac R, Merchant, 1016 Walnut st L
Smith, James Brown, 433 Arch st L
Smith, J F, Civil Engineer, Reading, Pa C
Smith, John, Machinist, 2331 Sepviva st C
Smith, J. Pancoast, 1923 Spruce st L
Smith, L F 2d
Smith, Randolph A, Bookkeeper, 1227 Parrish st C
Smith, R Morris, Architect, 3715 Chestnut st C
Smith, R R, Lawyer, 733 Walnut st C
Smith, Samuel, Druggist, S 3d st L
Smith, Wm, Mech Draughtsman, 912 N Front st C
Smith, Wm Bugbee, Draughtsman, 5th and Washington ave C
Smith, Wm H, Sugar Refiner, 427 Vine st C
Smith, W H, Jr, Stationer, 811 Arch st C
Smith, Wm M, Machinist, 723 Jayne st C
Smyth, L, Sugar Refiner, 1120 Arch st L
Smyth, Wm C, Sugar Refiner, 921 N Broad st C
Snider, Geo, Bookbinder, 2311 Spring Garden st L
Snyder, Eliza C, Teacher, 1829 Chestnut st C
Snyder, Henry 1st
Snyder, M B, Astronomer, 542 N 13th st C
Somerville, Jas. McA, M.D, 1714 Race st L
Soule, Richard H, Asst. Supt., 5th and Washington av C
Spare, Benj. F, Carpenter and Builder, 344 N 15th st C
Sparks, Thomas W, Clerk, 121 Walnut st L
Speakman, Thomas S, 532 Cooper st, Camden, N J C
Speel, Joseph, Bookbinder, 25 N 7th st L
Spellier, Louis H, Watch Maker, Doylestown, Pa C
Spence, Jas., Steam Heating, 1108 Fairm't av C

Spencer, J. A, Attorney-at-Law, 423 Walnut st C
Spittal, John, Wood Engraver, 409 Chestnut st L
Spon, E, Technologist, 442 Broome st, N Y C •
Spor, Joseph, Machinist, 2129 South st C
Sproat, H. Eric, Civ. Eng, 313 S 10th st C
Stabler, John, Commission, 501 Chestnut st C
Starr, Edwin P, Stype. Founder, 324 Chestnut st C
Starr, Isaac, Merchant, 1417 Spruce st C
Starr, Sam'l, Camden Iron Wks. Camden, N J C
Starr, Thos. W, Type Founder, 324 Chestnut st C
Stauffer, D. M, C.E., 2617 South st C
Steel, James W, Engraver, 320 Walnut st C
Steinmetz, Adam, Steam Marble Works, 1029 Ridge av C
Steinmetz, Chas, Bookkeeper, 1029 Ridge av C
Steinmetz, Howard, Marble, 1029 Ridge av C
Stelwagen, Jos, Paper Mfr, 525 Commerce st L
Stellwagon, Thos. C, D.D.S, A.M., 1627 Chestnut st C
Sterling, Andrew, 1607 S 2d C
Stevenson, Cornelius, 603 Walnut st L
Stevenson, Wm. C, Jr, Drugs, 24 S 4th st 2d
Stewardson, John L
Stewart, Alexander, 224 S 5th st 2d
Stewart, Frank, Physician, 113 S 7th st L
Stewart, Harry, Draughtsman, 1600 Hamilton st C
Stewart, John L, Oil Refinery, 1148 S Broad st C
Stewart, Thomas S, Architect, 623 S 10th st 1st & L
Stileman, R. T. H, Hydraulic Machines, 1091 Germantown av 2d
St. Ledger, J. J, Machinist, 1909 South st C
Stockham, Chas. Jr., Lumber, 215 Cooper st, Camden, N J C
Stockton, Alex. D, Clerk, 510 N 4th st C
Storer, G. W, Mech. Eng, 2010 Brandywine st C
Stout, A. M, Lawyer, 705 Sansom st C
Stout, Watson, Heaters and Ranges, 1216 Struthers st C
Stover, Lewis, Attorney, 522 Walnut st C
Straake Frederick, Manufacturer, 20 N 5th st L
Stratton, Harrison D, Machinist, 146 N 11th st C
Stratton, Matthias, Gas Fitter, 719 Walnut st L
Stratton, Wm, Gas Fitter, 719 Walnut st L
Stratton, Wm. A, Grocer, 197 Cherry st L
Strawn, Joel W, Chemist, 116 N Del av C
Strode, Humphrey M, Bricklayer, 407 N 5th st C
Strode, Joseph C, Hydraulic Engineer, Phila. Postoffice L
Strohm, Samuel D, Dentist, 117 Laurel st C
Stroud, Wm. C, 2110 Mt. Vernon st 1st
Struthers, J. Strickland, Merchant, 313½ Walnut st L
Struthers, Wm, Stone Cutter, 1022 Market st L
Sturdivant, Horatio W, Engraver L
Sturgis, Robert S, 1815 Walnut st C
Sulgar, Abraham, Dry Goods, 218 Arch st L
Sumner, John, Blacksmith, 531 N 20th st 2d
Sunderland, Wm C, Builder, 4215 Sansom st C
Suplee, N. R, Machinist, 1527 Arch st C
Supplee, Chas. D, Carpenter and Builder, 203 S 4th st C
Sweatman, V. Clement, Accountant, 1508 Green st L
Sweetapple, Edward, Paper Maker, Elkton, Md C
Swerchesky, J. Gustavus, Physician, 121 Susquehanna av C
Sykes, Joseph, Machinist, 1014 Shackamaxon st C
Sylvester, Louis, Mech. Eng, 1805 Walnut st C

Taber, George, Sec, 233 S 4th st L
Taggart, Edward D, Agent, 104 N Del av C
Taggert, Wm, Mech. Eng, 1103 Coates st C
Talmage, Eben S, Bookbinder, 114 S 3d st C
Tardif, Wm. Jr, Laundry, 220 N 20th st C
Tasker, Thomas T, 1622 S 5th st L
Tasker, Thomas T. Jr, M'f'r, 2020 Walnut st L
Tate, William J, Machinist, 410 N 12th st C
Tatham, Benjamin, M'f'r, 82 Beekman st,, N Y L
Tatham, Edward, 1114 Spruce st 1st
Tatham, George N, M'f'r, 1114 Spruce st 2d
Tatham, George N., Jr, 1114 Spruce st 1st
Tatham Henry B., Jr, 226 S 5th st 1st
Tatham, James, 226 S 5th st 1st
Tatham, Wm. P, M'f'r, 226 S 5th st 1st & L
Taylor, Frank H, Artist, 113 S 4th st C
Taylor, Geo. E, Tin Plate, 301 Branch st C
Taylor, George W, 50 N. 4th st L
Taylor, Henry P, 648 N 10th st C
Taylor, John, 109 S Broad st C
Taylor, Stacey, House Carpenter, Grier bel 13th st L
Teal, Chas A, Machinist, 3029 Chestnut st C
Teal, Peter, Machinist, 12 Morgan st L
Tener, Rob't, Coal, 955 N Front st C
Tennent, John, Stock Maker, Mt Airy L
Tetlow, Henry, Toilet Soaps, 122 Arch st C
Tetlow, J K, Type Founder, 1523 N 13th st C
Thackera, B, Manufacturer, 718 Chestnut st C
Thomas, A W, Manufacturer, 801 Race st C
Thomas, J V, Iron Master, Centre co, Pa L
Thomas, Lancaster, Apothecary, Broad and Ellsworth sts C
Thomas, Pliny, Locksmith, 17th ab Arch st C
Thomas, Reynold, Clerk, 304 Walnut st C
Thomas, Sam'l A, Gas Engineer, 420 N 11th st C
Thomas, Theodore, 2019 Delancey st 2d
Thompson, Ambrose W, L
Thompson, David 1st
Thompson, Franklin A, Heaters and Ranges, 137 N 10th st C
Thompson, Geo, Manuf, 900 Pine st L
Thompson, John J, 2024 Spruce st 1st & L
Thompson, J P, Merchant, 609 Market st C
Thompson, Thomas, Stone Cutter, 1227 Spring Garden st L
Thompson, Wm J 1st
Thomson, E, Chemist, 2134 Fitzwater st C
Thomson, W R, House Carpenter, 1413 S 2d st C
Thorn, Fred G, Architect, 233 S 4th st C
Thorne, Wm H, Machinist, 21st ab Market st 2d
Thurston, Rob't H, Prof. Mech. Engineering, Steven's Institute, Hoboken, N J C
Tilghman, B C, Lawyer, 1114 Girard st L
Tilghman, Edward 1st
Tilghman, Richard A, 321 S 11th st 1st & L
Tiller, Sam'l, Copper Plate Printer, 815 N 15th st L
Todd, Wm E, Machinist, 1365 Beach st C
Todd, Wm H, Lawyer, 704 Walnut st C

Toland, Geo W, 2039 Pine st L
Torr, J Nelson, Printer, 110 S 3d st C
Towne, Henry R, Stamford, Conn 1st
Townsend, E. Y., 218 S 4th st 1st
Townsend, I, Manufacturer, 329 N 11th st C
Tracy, E. Watch Case Maker, 104 S 6th st L
Tracy, Miles S, Brass Founder, 625 Summer st C
Trainer, W E, Cotton Manuf., Linwood, Del co, Pa C
Trautwine, J C, Civil Engineer, 530 N 6th st L
Trautwine, John C, Jr, Clerk, 1608 Market st C
Travis, J L, Brass Works, 241 Arch st C
Tray, William, 2029 Callowhill st C
Trogo, Chas B, Teacher, 186 Pine st L
Troth, Sam'l N, Physician, S W 7th and Thompson sts 2d
Trotter, George, 218 S 4th st 1st
Trotter Wm. H., Merchant, 36 N Front st C
Truitt, Jos P, Wool Manufacturer, Darby, Pa C
Trueman, Wm H, Dentist, 511 Spruce st C
Truman, Alex S, Hardware, 835 Market st C
Truran, John, Draughtsman, 5th and Washington ave 2d
Tucker, Christopher, 1441 N 17th st C
Turnbull, Lawrence, Physician, 1208 Spruce st L
Turner, Ernest, Surveyor 1st
Tweedale, Thomas, Moulder, 522 N 6th st C
Tyson, S. T, Merchant, 1210 Market st C

Uhlinger, W P, Machinist, 22 E. Canal st. C
Ulmer, Levi B, 1620 Swain st 2d
Unger, John F, Civil Eng, 431 Master st C
Unstead, Isaac E, Civil Eng, Pottstown, Pa C
Ustick, Stephen, Machinist, 134 S 4th st C

Vail, Hugh D, 1927 Mt Vernon st 2d
Van Artsdalen, Jas T, Engraver L
Vance, James M, Hardware, 1629 Girard av L
Vandergrift, G J, Engineer, 1708 Sansom st C
Van Horn, Ed D, Brush Manuf, 1009 Arch st C
Vanhorne, M K, Carver, 186 S 11th st L
Vaux, George, 1715 Arch st C
Vaux, Wm S, 1702 Arch st L
Veale, Moses, Attorney, 402 Walnut st C
Verree, J P, Manufacturer, 939 N Del av C
Ver Kouteren, A Y, Dr'tsman, 503 N 20th C
Van Haagen, A, Soaps, 2518 Callowhill st C
Van Haagen, C, Machinist, 2518 Callowhill st C

Wagner, H D, Mech. Eng'r, 1819 Spruce st C
Wagner, Wm, 17th and Montgomery av L
Wahl, Wm H, Chemist, 1436 N 13th st 2d
Walanta, Edmund, 1616 Sydenham st 2d
Walborn, Cornelius. A, 81 N 6th st L
Walder, John H, Mechanical Engineer, Germantown, Pa L
Walker, Abraham, Wagon Builder, 20th and Filbert sts C
Walmsley, W H, Merchant, 921 Chestnut st C
Walsh, Moses, Chemist, 122 Walnut st C
Walther, Fred'k, Optician, 703 Thompson st C
Walton, C. Hardware Dealer, 625 Market st C
Walton, W K, Manufacturer, 262 S 2d st C
Wallace, John Wm, 728 Spruce st C
Walter, Thos U. Architect, 720 N Broad st L
Walton, C W, Manufacturer, 413 Arch st C
Wanich, Alex. Machinist, 1410 Hanover st 2d
Ward, Chas, Engineer, 268 S 9th st C
Ward, G M, Physician, 268 S 9th st C
Warder, J H, Engineer, Indianapolis, Ind L
Wardle, Thomas, 465 Arch st L
Warner, Cuthbert, Instrument Maker, 2327 Fairhill st C
Warnich, Alex., Machinist, 1410 Hanover st 2d
Warren, E. B , Roofer, 1013 Spruce st C
Warren, Samuel D., Merchant, 17 State st., Boston, Mass. L
Warrington, James, Merchant, Camden, N. J. L
Waters, Chas., Machinist, 8 Province st., Boston, Mass. C
Watson, Andrew, Machinist, 538 E Cumberland st C
Watson, Jas., Machinist, 1608 S Front st 2d
Watts, Geo. W., Draughtsman, 1057 Richmond st 2d
Weaver, John J., Plumber, 7th and Filbert st C
Webb, S. Wm. F., Clerk, 16 Logan Square. L
Webster, John T., Designer, 3504 Fairview st C
Wehn, Geo. H., Artificial Stone, 911 Filbert st C
Weightman, Wm., Chemist, 9th and Parrish st L
Weigley, W. W., Attorney, 702 Chestnut st C
Weigner, J B, Carpenter, 1033 Lawrence st 2d
Weir, W. B., Notary, 3936 Chestnut st C
Weldin, Lewis C., Student, 1104 Spring Garden st C
Welsh, Ashbel, C.E., Lambertsville, N. J. L
Welsh, Chas., Engraver, 1617 Mt. Vernon st L
Welsh, John, Merchant, 1034 Spruce st 1st & L
Welsh, Samuel, 304 Walnut st 1st
Welsh, Wm, Merchant, 1122 Spruce st 1st & L
Wernicke, A. C., Teacher, 219 N 16th st C
Wernwag, Wm., Baker. L
West, Edgar C., Bookkeeper, 1211 Mt. Vernon st C
West, Edwin, Bookkeeper, 1015 N Del. av C
West, Henry F., Mfr., Gloucester, N. J. C
West, John, Mechanical Engineer, Bethlehem, Pa. L
West, Thos., Smelter, 212 E Thompson st C
Westinghouse, Geo. Jr., Pittsburgh, Pa. 1st
Weston, H. James, Engineer, 2029 Callowhill st C
Wetherill, Thos., 1529 Locust st C
Wharton, B. B. H., Chief Engineer U.S.N., 1506 Spruce st C
Wharton, Jos., Nickel Works, 125 S 12th st C
Wharton, Jos. S. L., Iron Founder, 15th and Wood sts C
Wharton, Wm. Jr., R. R. Builder, 1506 Pine st C
Whartenby, Thos. L
Wheeler, Elbridge, Inventor, Saunders av., W. Phila. C
Wheeler, Jos. K., 2626 Chestnut st L
Whelan, Chas. S., 309 Walnut st 2d
White, Chas. H., Cabinet Maker, 723 S 10th st L
White, Duncan, Mfr., Norristown Pa. C
White, Henry J., Heaters and Ranges, 21 S 7th st C
White, Sam. S., Mfg. Dentist, 12th and Chestnut st 1st & L.
Whitman, Geo., Brick Maker, S. E. cor. Spruce and 11th st L
Whitney, Geo., Engineer, 16th and Callowhill sts L

Whitney, Jas. S., Mfr., 16th and Callowhill st L
Whitney, Jno. R., Mfr., 16th and Callowhill st L
Whitney, Thos. J., Sewing Mach, 1530 N 17th C
Wickersham, C., Attorney at Law, 124 S 6th st L
Wickersham, Morris S., 247 S. 3d st L
Wiedersheim, John A., Patent Solicitor, 110 S 4th st C
Wiegand, John B., 1033 Lawrence st 2d
Wiegand, Jno., Prest., 1000 Walnut st 1st & L
Wiegand, Jno. Jr., 45th st & Osage av L
Wiegand, S. Lloyd, Engineer, 124 S. 6th st. L
Wiegand, Thos. S., Apothecary, 528 Arch st C
Wilbraham, J. W., Sr., Machinist, 2316 Frankford road
Wilbraham, J. W., Jr., Machinist, 720 E. Cumberland st C
Wilcocks, A., Physician, 2133 Walnut st 2d
Wilcox, Austin O., cor. Broad and Parrish sts L
Wild, Chas E, Sup't Print Works, Chester, Pa C
Wildman, Elias, Dentist, 1205 Arch st C
Wildman, E. D., Architect, 426 Walnut st C
Wiler, Wm., 225 S 5th st 2d
Wiley, Jos., Druggist, 154 N 3d st C
Wilford, Jno. B., Draughtsman, 1506 N 22d st C
Wilhelm, Chas., Lamp Maker, 919 Race st L
Willard, D. D., Iron Mfr., 1724 Spruce st C
Willcox, Jos., 1314 Arch st C
Williams, Henry J., Attorney, 712 Walnut st L
Williams, Albert B., C.E., 617 Franklin st C
Williams, Chas., Heaters and Ranges, 1132 Market st C
Williams, Chas. B. L
Williams, Chas. B., Merchant, 611 Market st C
Williams, C. D., Salesman, 712 Cherry st 2d
Williams, Edward H., 500 N Broad st C
Williams, Geo. W., Machinist, 946 Kurtz st C
Williams, Isaac S., Tin Plate Worker, 728 Market st C
Williams, N. W., Engineer, 710 N 10th st C
Williamson, Jno., Lumber Merchant, 45th and Lancaster av. L
Williamson, Wm. C., Engineer, Richmond and York sts C
Willitts, Alfred, Furniture, Holmesburg, Pa. L
Willits, Jas., Bricklayer, 1629 Mt. Vernon st L
Willits, T., Merchant, 152 N. 4th st C
Wills, E. S., Carpenter, 248 Marshall st C
Wilson, C. G., Hardware, 508 Commerce st 2d
Wilson, C. R., C. Eng. 225 S. 6th st C
Wilson, E. H., Clerk, 1500 Green st 2d
Wilson, E. L., Publisher, S.W. 7th & Cherry. 2d
Wilson, H. A., 512 Marshall st 1st
Wilson, H. H., 512 Marshall st 1st
Wilson, J. A., Civ. Eng. 410 Walnut st L
Wilson, J. L., Civil Eng., 512 Marshall st 1st
Wilson, Jos. M., Chief Eng. 233 S. 4th st L
Wilson, J. M., Salesman, 338 S. 15th st C
Wilson, O. H., Merchant, 215 N. Water st L
Wilson, W., Manufacturer Paper Hangings, 18th and Washington av C
Wilson, W. C., Paints, 105 S. Front st 2d
Wilson, W. H., Civil Eng. 233 S. 4th st L
Wiltberger, H. A., Bookkeeper, 3947 Market st L
Windrim, Jas. H., 219 S. 6th st 1st
Winebreiner, David. L
Winebrener, T. E., 1409 Walnut st C
Winsor, H., Merchant, 338 S Delaware av C
Winsor, W. D., Merchant, 338 S. Delaware av C
Wise, C. E., Aeronaut, 1951 N. 11th st C
Wise, John, Aeronaut, 1951 N. 11th st C
Wise, Saml. C., Carpenter, 220 McAlpine st C
Wolf, T. R., Ph. D. Chemist, Newark, Del. C
Womrath, F. K., Furrier, 710 Arch st C
Wood, A., Iron Manufacturer 1525 Arch st L
Wood, A. Jr., Conshohocken, Pa. L
Wood, George R., 218 S. 4th st 1st
Wood, H. C., Merchant, 612 Race st L
Wood, H., Manufacturer, Conshohoken, Pa. L
Wood, J. T., 8th and Cherry, Camden. 2d
Wood, Robt., Ornamental Iron, 1136 Ridge av L
Wood, T., Manufacturer, 1836 Green st L
Wood, T., Machinist, 2106 Wood st C
Wood, W., Manufacturer, 400 Chestnut st 1st
Wood, W. W. W., Eng. in Chief, U. S. N., 108 Walnut st L
Woodbridge, J. E., Draughtsman, Chester, Pa. C
Woodruff, C. H., Merchant, 4 Arch st C
Woodruff, G. J., Machine Works, Norristown Pa C
Woodruff, T. T., Machinist, S. W. Broad and Brown sts C
Woods, J., Nashville, Tenn. L
Workman, H. Weir, Broker, 123 Walnut st C
Worrall, A., C.E., 627 Wood st C
Worthington, H. W., Bookkeeper, 449 N. 5th st C
Wright, J. H., Teller, 34 S. 3d st C
Wright, J. K., Oil Silk Mfr. 2322 Green st L
Wright S. Machinist, 404 New Market st C
Wright, S., Umbrellas, 324 Market st C
Wright, W. R., Draughtsman, 531 N. 22d st C
Wyand, Daniel, Shoemaker, 1207 Pine st C
Wyckoff, E S, Physician, 6th and Arch sts C

Yarnall, Hibbert, Builder, 21 N 7th st C
Yeager, Jno. C. L
Yeager, John E, Stair Builder, 1415 Vine st C
Yost, Thomas W, Merchant, 28 N 9th st C
Young, George, 515 Pine st 2d
Young, Lewis T, Salesman, 700 Passyunk av. C
Young, Richard, Distiller, Morton Del Co, Pa L
Young, S. H.
Young, Wm. S., Printer, 727 Jayne st L

Zentmayer, Chas, Optician, 147 S 4th st C
Zentmayer, Jos, Optician, 147 S 4th st C
Ziegler, George J., M.D., 128 S 15th st L
Ziezemiss, Edwd, Clerk, 304 Walnut st C
Zimmerling, C, Sugar Refiner, 611 N 18th st C
Zook, J M, Bookkeeper, 1330 Buttonwood st C
Zorns, Chalkley, Milk Dealer, 1409 Frankford st C

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXXI. JANUARY, 1876. No. 1.

EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors, the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Industrial Art.—The universal enjoyment of beauty, in form and in color, whether exhibited in natural or artificial objects, and the changes of appreciation and increase of gratification, which proceed from custom, fashion, and habit, is a fact in human, if not also in animal nature, whose existence and influence must be admitted. Cleanliness, neatness and order, either in person, clothing or the commoner accessories of civilized life, form one standard of beauty, for the attainment of which half the lives of woman, if not of mankind, is devoted; and passing this lowest standard of luxury, every rank, station, or condition of life establishes and values some relative tastefulness in its belongings. The writer well remembers how the monotony of a long railroad journey was relieved from the continued perspective of frozen level fields, by the back view of two bonnets, made from dove colored silk, of artistic perfection and spot-

less beauty, with plaits in the most regular folds, enveloping the shape of the lovely coal scuttle, and with the radiant point of plaiting hidden by the neatest of minute bows. The geometrical considerations upon the lines of intersection indicated by the folds, were scarcely more abstruse and insolvable than the theological reflection suggested by the show of taste; and it is yet an undetermined question whether those particular bows were pomps or vanities, or a special dispensation. Even professed abnegation will not annihilate the fashion. When reduced to the elements of bare requirement, the Friends' male attire becomes something surprising. Given any article of necessity, comfort or luxury, no asceticism has ever overcome the love and desire for the beautiful; predominant always when necessity or comfort are equal, and frequently asserting themselves over either needs or desires.

With this existing and universal fact of demand, neither excellence nor cheapness of production warrants those who are engaged in industrial pursuits in neglecting the knowledge, or more properly the educated ability, of the artist. Whatever is made to be sold, especially must—regardless of the homeliness of purpose—have beauty of design or of color, together with good workmanship. All these qualities go to make up a value or price to the purchaser.

But it must not be assumed that because the desire for prettiness is pervading, and because there is an individuality in estimation or choice of handsome things, therefore taste is a matter of fashion, style or caprice; that either general demand by the most votes, or the personal opinion of one individual will suffice to make handsome things. Capability to design, either in line or color, comes to no one as Dogberry has it "by nature;" nor does individual or national appreciation of beauty become elevated, much less perfect, except after study, or at least familiarity with good examples. Owen Jones calls his book the "Grammar of Ornament" and there is a great propriety in the name. The laws of design are as definite as those of language, with much the same questions as to order, relationship, construction or elegance; differing for dissimilar styles as for divers tongues. The pupil in design has similar obstacles to encounter with those of the schoolboy in his alphabet and grammar; the ability to use the pencil or the brush will no more produce an artist, than the acquirement of the writing master's art, combined with all of Murray's rules, will make a poet; and a parallel kind of education to that which supplies admirers for the picture, gives readers for the poem.

A style of architecture or of line or color decoration may be appropriated and accompanied with incongruous details or effects, and the result may be striking, admired or fashionable, but with examination or time will depart the gratification of first view and a simple feeling of ugliness will follow.

Except that the principles of ornament have been read about and investigated far enough to discern, few people, only those with artist eyes—eyes which but rarely are found in northern European nations or their descendants—can recognize the fitting nature of each ornament to its style, and how painful to the unlearned, as well as to the learned, are departures from rules. This condition of taste can be well exemplified in any dry goods shop, by looking over a collection of old prints and seeing how some of them seem uncouth in line, irregular and unsatisfactory in color, while others of the same type and fashion produce at once an impression of suitability, elegance and beauty. One remarks that nobody would wear such a pattern to-day, but it is very pretty, or showy, or effective! Why these characteristics attach to some of the patterns and not to others, the educated artist can at once detect. Not that everything which is handsome is in style to sell, but that that which is in style and is handsome will sell best. Every maker or seller of jewelry or ornaments, carpet, or hangings, of prints or laces, finds some patterns which sell with great regularity, while others which may sell rapidly at first, quickly lose all demand; and most accomplished salesmen can select with certainty what will probably sell, after novelty has passed away.

The writer has a considerable collection of fashion plates for the present century, and interspersed with them are "fancy dresses" of corresponding dates. Remarkably, not singularly, the fancy dresses of 1800–10, 1810–20, 1820–30, 1830–40, 1840–50, and so on, *are all alike*, however dissimilar the style of dresses which varied from skirts three-quarters of a yard to those of six yards in circumference, within those dates. The *elegance* of all these costumes was found in their approximation towards the fancy styles at any time. This example is strictly not quite applicable to the question of educated taste now under consideration, but the analogy is a correct one.

The attempt to combine beauties by appropriation of an ornament here, a decorative line there, the copy of red roses from one pattern upon the beautiful pearl ground of another, is a feature of English

and of American industrial art; very cheap, very unintelligent, very inartistic, and it is gratifying to add, very unprofitable. The purchaser says there is an "I don't know what" about it, but she buys a French print or a piece of French jewelry when the English, German or American fabric is much more durable and intrinsically valuable, and is in so far better educated in art than the Germanic or native maker or seller.

The education of the buyer in art is one of comparison, not one of reasonable ground for estimation, but however attained, this education has now reached an eminence far above our native capability to supply. A person does not stop to estimate the strength of the bridge which carries him over the stream. No one who has a rational enjoyment in his dinner, desires to know much of the mysteries of the kitchen; outside of mechanics' lectures and useful-information periodicals, (which are imagined to have listeners or readers), the knowledge of an art is as great a bore as the enjoyment of its results is a pleasure. As in letters and as in music, so in art: the public taste becomes elevated by examples rather than by reasoning. The competition of examples is raising the standard in all regards.

Take, for instance, the painter's art. The competition of the photograph has given us a standard of correct drawing, shadow, and perspective, previously unknown. Forty years ago it sufficed to sketch a background, and the eye was demanded to tolerate errors of fore-shortening by the best of painters. To-day, no leniency can be admitted in these regards. The competition of the chromograph has already softened incongruous tints, and compelled the use of permanent colors of high natural tones. It is not supposed that either the photograph or the chromograph will take the place of the painting, but it is certain hereafter, that the painting must be superior in finish, in excellence, and in effectiveness to them.

In industrial art there are no photographs possible. The only mechanical additions to the art of design have been the engine lathe and the kaleidoscope. The use of the former has been fully availed of in its limited direction, but the arabesques of the latter in line and in color are yet to be made use of in many applications.

The field of industrial art is of great extent and comprehension; the line between it and architecture is very imperfectly marked; furniture, wall decoration, carpentering, carving, etc., are adjuncts to the architect's work in churches, halls or houses. In such

branches—for industrial art must divide into branches, both in study and in practice—a knowledge by no means incomplete, of the corresponding art must be attained by the artist. But by far the most difficult and important study of industrial art, after the acquisition of the laws and rules of decoration, is the capability of the material to be treated, and the utilizing of the methods of decoration at command.

Take the well known examples of method. The sand-blast which promised so beautiful results five years since, yet lingers comparatively unproductive; and mechanical wood carving has so far failed in effective or really tasteful work, while all artists admit the difficulties in both cases to lie in the want of designs, not in the method.

Unquestionably, many persons who have noticed the proposal to establish a school of design in Philadelphia, have looked upon the plan as kind of easy amateur procedure; that a few lessons in handicraft would allow the student to compete for a prize, and qualify him or her to decorate, or at least design a decoration, in some style, either florid or severe; but such persons or their friends will learn with dismay, that given the highest of talent, years of study and pursuit alone can attain eminence, and that few will ever reach mediocrity. All that education can do is to teach. Application, readiness, invention, DESIGN, can only come to the educated mind and skillful hand, and the natural gift of art ability.

If this city—if the nation—is to secure and maintain its eminence as a manufacturing one, it must do it through its ability, not through its machinery, handicraft, or its cheapness of production. In some branches of workmanship the mechanical excellence and inventive superiority will keep the business in the hands of our mechanics, but even here the coupling with taste, both in form and color, will prove advantageous; but in the textile fabrics, the furniture and jewelry, only original designs, not borrowed, not misunderstood or misappropriated, will preserve the tradesman and the workman from the local competition of every country town. The competition of unskilled labor is always destructive.

The success of a School of Industrial Art rests upon the same basis as the success of schools in other branches of learning. First of all, upon the value which the Community shall set upon knowledge acquired; what pre-eminence, distinction, or reward shall be attached to the acquisitions of the student. Secondly, the Students; under

the stimulus of elevated aims and hopes, the standard of selection of students can be brought to a high point, in mental, educational and natural artistic ability, and the efforts and labors of students will have corresponding energy. Lastly, the Tutor; although the before-named conditions are the more essential, and although with a mere schoolmaster, the school may thrive, yet eminence in all things is individual, and attainments of the highest order, with capacity to impart them, must be sought and secured to fill the place.

It would almost seem proper that the school be made one of the branches of technical education, which are now being grouped in one general head by the University of Pennsylvania at West Philadelphia, as has been done at Boston in Massachusetts Institute of Technology, where an industrial art class has already attained high prominence; but this suggestion may not be open to consideration until after the school shall have secured its independent support, which we think is the case at Boston. As remarked before in this paper, the kindred arts of mechanics and architecture are associated intimately in processes and results, and it would appear that with these studies, industrial art should also be associated.

Announcement of Lectures to be given before the Franklin Institute at their Hall, commencing Tuesday, January 4th, 1876:

One Lecture by Dr. C. B. Dudley, on Artificial Ice,
January 4th.

Three Lectures by Mr. Robt. Briggs, on Steam Boilers,
January 6th, 13th, 20th.

Two Lectures by Prof. E. D. Cope, on Paleontology,
January 11th, 18th.

One Lecture by Mr. Jos. Zentmayer, on Lenses,
January 25th.

Five Lectures by Prof. P. E. Chase, on Natural Physics,
February 1st, 8th, 15th, 22d, 29th.

Two Lectures by Prof. Persifor Frazer, on Geology,
February 10th, 17th.

One Lecture by Prof. M. B. Snyder, on Stellar Spectroscopy,
March 2d.

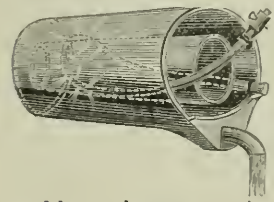
Two Lectures by Prof. L. M. Houpt, on Tunneling,
March 14th, 21st.

Two Lectures by Prof. R. E. Rogers, on Chemical Force.
March 16th, 23d.

BLAST-FURNACE TUYERES.

FRANCIS H. LLOYD.*

SIR:—My attention has been called to the remarks on "The working of Blast-Furnaces," with reference to the recent tuyere accident, in the *Journal* of Sept. 25. Your correspondent's challenge to ironmasters, who believe they have overcome the difficulty and danger arising from tuyere explosions, to make their success widely known, leads me to address you on the subject. I claim to have completely overcome the difficulty by doing away altogether with water jacketed or coiled tuyeres, and substituting a tuyere casing of about the same dimensions as the tuyeres in general use, but open at the outer end, and containing between the walls of the tuyere casing a spray pipe, throwing a sufficient supply of spray or small jets of water on the rear end and sides of the tuyere to prevent it from overheating or burning. More than 50 of these tuyeres are now in use with uniformly satisfactory results; they are more durable than other tuyeres, and are entirely free from risk of explosion. If through long wear or deficient water supply a tuyere should become defective, there need be no haste as to its removal, as no immediate harm can arise; any defect is at once apparent from the open end of the tuyere. We have now had these tuyeres in constant use at one furnace since last November, and since February last we have adopted them exclusively at two furnaces; they are now being adopted at a considerable number of furnaces elsewhere, and at three furnaces, besides those with which I am connected at Darlaston Green, they have been in use for many months. Many furnace managers have seen them at the Darlaston Green furnaces, and no one has ever doubted their safety, nor has any one who has tried them found them inefficient in any particular. The furnace keepers have far less work than where other tuyeres are in use, and are perfectly free from danger; besides this, the saving in actual cost of renewal of tuyeres we have found to be an important item, and the extremely rare occurrence of a stoppage for tuyering a still more important one. I shall have much pleasure in showing the



* From the *Mining Journal*, London, October, 1875.

tuyeres in use to any of your readers who are interested in the matter; and I trust ironmasters will no longer be open to the reproach made in the remarks in the *Journal*, that we "are compelled to sit down under a sense of an inability to help ourselves in such a matter."

Wood Green, Wednesbury, Oct. 13.

A Non-Retreating Bunsen Burner.—The low pressure of gas which prevails during the daytime in many places causes not a little inconvenience in the use of Bunsen burners of the usual form, as these are liable under such conditions to retreat when moved slightly, or when exposed even to such moderate currents of air as are produced by the motion of a person walking past them.

To obviate this inconvenience, which he had experienced in his own laboratory, President Morton, of Hoboken, has devised a burner which seems to meet the difficulty in a simple but scientific manner.

Considering that the retreat of ordinary burners was occasioned by irregularities of the nature of eddies in the flow of the ascending explosive mixture, by which its rate of ascent was reduced locally below that at which such mixture would burn downwards, he draws in the upper end of the main tube so that the mixed gases escape through what may be regarded as an aperture in a thin plate.

This presents, as is well known, the conditions requisite for a smooth vein, in the case of liquids, and inferentially in that of gases.

In fact, the burners so made have proved very satisfactory in actual use. The large burners will work under very low pressures, and smaller ones may be burned down until actually extinguished without any adjustment of air supply, and yet without possibility of retreating.

Medal from the U. S. Government to Prof. Henry Draper, of New York.—The very valuable assistance rendered to the Commission upon the Observation of the Transit of Venus, has been recognized by the presentation of a gold medal in testimony thereof.

The obverse of the medal has a figure of the heliostat employed by Doctor Draper in his preparatory labors with the photographers in practice; and the inscription, FAMAM EXTENDERE FACTIS HOC VIRTUTIS OPUS EST, ("To extend fame by deeds is a work of virtue."—*Virgil*); and the reverse is inscribed VENERIS IN SOLE SPECTANDÆ CURATORES R. P. F. S. HENRICO DRAPER, M. D., DEC. VIII, MDCCCLXXIV, ("The Transit of Venus Commission of the United States to Henry Draper, M. D., December 8th, 1874,") with a circle inscription around the edge, VIRTUS VIRTUTI ADDIT AVITO, (he adds luster to ancestral merit). Such public recognition of eminent worth or accomplishment has been rare by our government, and in this instance, particularly scientific men in our own country and in other lands will be gratified by its appropriate presentation.

Franklin Institute.

Hall of the Institute, Dec. 15, 1875.

The stated meeting was called to order at 8 o'clock P.M., the President, Dr. R. E. Rogers, in the chair.

There were 110 members present.

The minutes of the last stated meeting, held November 17th, ult., were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting the following donations were made to the library:

On the Dynamical Law of Horse-power of Steam Boilers, by John W. Nystrom, C. E., Philadelphia, 1875. From the author.

Twenty-third Annual Report to the Council of the City of Manchester, on the working of the Public Free Libraries, 1874–75. From Manchester City Councils.

The Actuary also reported that the Committee on Science and the Arts have recommended the award of the Elliott Cresson Gold Medal to W. G. A. Bonwill for improvements in his Electro-Magnetic Mallet for dental purposes, and the award of the Scott Legacy Premium and Medal to C. Tyson for his machine for uniting the soles to boots and shoes, which recommendations were received, ordered to lie over one month, and be reported to this meeting of the Institute.

Also, that a letter from H. Dumont Wagner to the Board, requesting them to elect a trustee to the Pennsylvania Museum and School of Industrial Art, was referred to this meeting.

The special committee appointed to co-operate with other bodies with the view of establishing an Industrial Art Museum, presented their report, which was read, and on motion of Prof. Houston was approved, and the committee discharged.

Mr. Hector Orr read the paper announced for the evening on "Atmospheric Electricity," its production and diffusion.

The Secretary presented R. E. Nichols' iron "Permanent Way for Railways;" H. Wrigley's automatic apparatus for working pumps on shipboard; Milford's patent sash holder and lock; Buck's bung faucet; W. G. A. Bonwill's electro-magnetic mallet for dental purposes, and Geo. Iles' differential compass.

The Meteorological Section presented its report which was ordered filed.

A report from the Committee on Science and the Arts, in relation to high pressure steam allowed by law on Western Rivers, embodying the following communication, to be signed by the officers and members of the Institute, and sent to both houses of Congress, was read, and on motion of Mr. Orr was adopted:

"HALL OF THE FRANKLIN INSTITUTE,

"Philadelphia, Dec. 15th, 1875.

"To the Honorable, the Senate and House of Representatives of the United States:

"The undersigned, members of the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, held at Philadelphia, in the State of Pennsylvania, respectfully represent that their attention has been directed to an amendment of an Act of Congress, entitled "an Act to provide for the better security of life on vessels propelled in whole or in part by steam," which amendment was approved December 17th, 1872, and which amended Act permits the use of an increased steam pressure in steam boilers of a certain class.

"By their Committee of Science and the Arts, they have examined the subject, and are of the opinion that the said increase of steam pressure allowed by the said amended Act, is not only improper, but prejudicial to the purpose for which the Act was originally enacted.

"At the request of a former Secretary of the Treasury, this Institute made a series of experiments for the purpose of determining the limits of safety, and means of preventing accidents in steam boilers, and made reports and suggestions upon those subjects, with a draft of a bill for the purposes of protection against accidents from steam boilers, which reports were accepted by the Secretary of the Treasury, and suggestions incorporated in various Acts approved by Congress.

"The said reports are likewise referred to as good authority, upon the subject of the strength of materials to be used for steam boilers, both in this country and in Europe, and the results and opinion expressed have been confirmed by the experience of British and French Scientists, and Government Commissions. We find that the increased pressure permitted by the amended Act of December 17th, 1872, will in many instances prove productive of accident, as permitting the use of steam pressures beyond the limits of safety, and we therefore respectfully recommend that so much of the Act referred to as permits of this increase of steam pressure be rescinded, and that a re-enactment be made, which shall restore the law as it stood before it was amended."

Prof. Houston moved that the meeting do now proceed to the election of a trustee to the Pennsylvania Museum and School of Indus-

trial Art as provided for in its plan of organization, and as communicated by letter from H. Dumont Wagner, Secretary, to the Board of Managers, and after considerable discussion, the motion was carried.

Mr. Durfee nominated the Secretary of the Institute to be *ex-officio* the trustee, and Prof. Houston nominated Mr. J. E. Mitchell. While the ballot was being taken Mr. Mitchell declined, and Prof. Houston moved that J. B. Knight be declared elected, whereupon, on motion of Mr. Hall, the motion to go into the election was reconsidered, and the further consideration of the subject of electing a trustee was postponed to the next stated meeting.

The President announced that in accordance with Section 7 of Article 14 of the By-Laws, the following nominations should be made at this meeting:

A President, Secretary, and Treasurer to serve one year; one Vice-President, eight Managers, and one Auditor to serve three years. The following members were then placed in nomination to be voted at the next annual election.

For President, R. E. Rogers, M.D.

For Vice-President, Henry G. Morris, J. E. Mitchell, Chas. Bullock (declined), and H. Cartwright (declined).

**For Secretary*, J. B. Knight and Wm. H, Wahl, Ph. D.

For Treasurer, Fred'k Fraley.

**For Managers to serve three years*, C. M. Cresson, Chas. H. Banes, Hector Orr, W. H. Wahl, Wm. Sellers, W. J. Budd, Robt. Briggs, J. W. Nystrom, Thos. Shaw, Sterling Bonsall, H. R. Hoyt, W. B. Bement, L. M. Houpt, J. Vaughan Merrick, H. Cartwright, C. Chebot, Richard McCambridge, H. W. Bartol, Wm. Adamson, J. E. Hoover (declined), Jas. Hunter, Geo. H. Hall, Cyrus Chambers, Jr., G. Morgan Eldridge.

For Auditor, Sam'l Mason.

The President appointed the following members to act as tellers at the annual election to be held January 19th, 1876:

Wm. A. Rolin, W. L. Dubois, Sam'l Sartain, W. Barnett LeVan, Wm. Taggart, John Canby, Geo. Gordon.

Mr. J. J. Weaver presented a series of resolutions addressed to the Board of Managers urging certain action on their part, looking to greater usefulness of the Institute, which was adopted.

On motion, the meeting then adjourned.

J. B. Knight, *Secretary.*

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* The following have since declined: Wm. H. Wahl, Ph. D., for Secretary; W. B. Bement and L. M. Houpt, for Managers.

Brief Note of Remarks on a Form of Pseudo Perspective for Illustration of Mechanical Objects.—Made by Robert Briggs, at the meeting of the Institute, September 15th, 1875.

The advertising of machinery, engines, tools and apparatus, has led to the publication of numerous pictorial price lists, circulars and hand-books, having as a necessary accompaniment, illustrations to which the text refers. It is highly desirable, that these illustrations should exhibit the general appearance and the general proportions of the objects to be advertised, frequently requisite to draw them in groups or classes, and often essential that they shall be drawn to some relative, if not absolutely to uniform scale. The larger and more comprehensive machines or engines should also be shown from such point of view as will convey to the mechanic or engineer (purchaser or user) an idea at once of the arrangement, and of the proportion of the several parts of which the machines or engines are composed.

A mere drawing from an artist's *vue d'œil* is *such* a verisimilitude as will be tolerated by no practical man. A photograph, as ordinarily taken with a short focus (and often cat-a-cornered), which can (if printed as a single card view) be reduced to perspective by holding to the eye, at some exact plane distance, may, from necessity, serve its purpose when isolated and examined alone. Such photographs, or engravings made from them, are very unsatisfactory for book illustration, not only from non-conformity of the plane distance with the proper book-reading one, but from the unsuitability of the plane distances with each other, together with dissimilarity of vanishing points and differences of angle of view. Many of the objections here stated attend pictures not made by the camera.

These considerations are sufficiently familiar to the intelligent engraver, and need only statement to him, but there are many other persons, more or less accustomed to books and pictures, who cannot have appreciated the bearing of these remarks upon the general illustrations daily observed by them. It is perhaps not saying too much, when the assertion is made, that most engravings are *not* seen or looked at as pictures in perspective, and that many people never see a picture as a scene, or endeavor to do so. Their eyes have become accommodated to a conventional representation, as really in false perspective as a Chinese drawing appears to be. Education has merely accustomed them to an arbitrary system of lines in which distance is imagined by reduction of size, and a picture *seems* to be correct, regardless of the ratio of the reduction. The Chinese perspective, without reduction, only fails in comparison to a miniature picture with an excessive angle of vision, by the admission of the existence of one correct point of view for the latter, although this point of view sometimes is chosen at less than eight inches from the eye.

To see a picture properly, the plane of the picture which is looked at *must* be at right angles to the line from the eye to the vanishing point, and the eye must be exactly so far removed from the picture as to give the real effect of relief and distance.

The angle of vision of a lens is much greater than that of the eye, and although some advantage is afforded in taking pictures by a camera, especially interior or street views, whereby the larger part of a room or an entire facade can be depicted on one plate, it must not be overlooked, that such views are purely arbitrary, and from no possible point of sight can they be correct. This defect of the lens becomes painfully apparent when a photograph of a large machine, erected in a small room, is assayed, and it is (so far as our eyes are accustomed to picture) aggravated when the object is so large that the camera has, so to speak, to look up at it.

The *civilized* perspective is the transcript of intercepted rays on a *vertical* plane, and the deviation of the plane from the vertical, which occurs when the negative plate is deviated, although in strict accordance with the perspective, and although if the place of the eye viewing the plate is made relatively that of the camera which took the picture, the visual difficulty disappears; yet the error of deviation of view condemns such a picture altogether.

These facts in perspective can be readily seen by examination of a set of photographs from nature, and can be made conspicuous to an audience by a lantern, as was done by several views at the meeting.

For the purpose of mechanical illustration, it is requisite that the details should be not merely sketched vaguely, but distinctly shown with draughtsmen's or photographic accuracy. No background or distance is desired, and the object should be isolated. Most objects have a front which it is desirable to exhibit. When some one front will not suffice to show all that is wished, two or more views looking at the machine at the sides or ends, are called for. The direct plane views fail to give any relief to projecting parts, even if deep shadows are thrown down, and it follows, consequently, that the object should be taken at a slight angle with the line of front. This angle had best not be excessive ; the front should predominate, and the retreating end should only give depth and projection to the outline.

Heavy sunlight shadows should not be made in any case ; the lines of shadows are confusing. Shades should be distinct, but subdued and dark lining is necessary for effect. The distant (or back) objects or lines should never be shaded or obscured, nor should the distance itself be shaded back, but the lines be lighter—*more distinct*—ending in the more remote parts in pure outline, unshaded and fine lined. It is to be noticed, that there being no background, the distance should die into the white of the paper.

These remarks apply as well to engravings with correct perspective as to those drawn as hereafter described, and the system of line drawing applies equally to mechanical and architectural drawings. Elevation, Plan, Section, etc.

In *drawings*, great effect and clearness is imparted by using black ink and broad dark lines for the front parts, clear black lines, but thinner and less pronounced for the parts behind, omitting all dark

lining on outlines further back, and by using very faint ink (still getting perfect lines) for objects behind the machine, or for distant walls. [For exhibition to the public, shaded architectural drawings are admissible, but for practical work in architecture and mechanics, a shade or shadow on a drawing is an evidence of idleness, if not incompetency.]

As a general rule, the objects to be depicted should be twisted to an angle of 9° to 10° (that is, the person, or camera viewing them should stand so that a given *depth* of side will appear on the perspective plane about one-sixth as long as the same dimension on the front view), and photographs or sketches from objects thus *posed*, if taken from long distances, so that the angle of vision for the entire figure shall be small, can be used singly or in groups on a page with much satisfaction.

If a group of articles of similar character are to be shown, it is very much better that the same point of view shall be taken for them so that the comparison, each with the other, can the more readily and positively be made.

This consideration leads away from a true perspective at once, and points to a mere projection. And it will be found that a plane projection at the angle designated, will differ so little from a true perspective for miniature views as generally looked at as to deceive any but a critical observer. In such projections it will be found advisable to consider the plane of vision above the object in the same position as was assumed at the side of it.

The kind of isometrical drawing thus obtained, differs from that usually practiced by the reduction of the proportion of side and top dimensions to those of the face, but the result of this reduction is to remove much of the obvious distorted effect. The system cannot be recommended either for large objects or for large views, and should be confined to miniature representations. Still in miniature representations of objects of considerable magnitude it can be adopted with success.

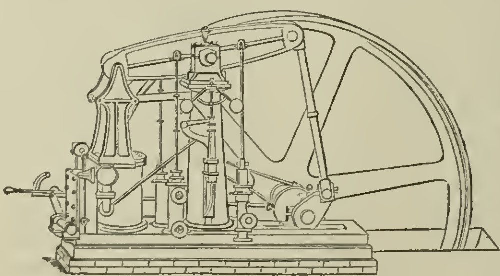


Fig. 1.

Figure 1 shows an outline sketch of an engine machine directly

from a working drawing to scale. This sketch is such as is required by the engraver on the block of wood before engraving and shading.

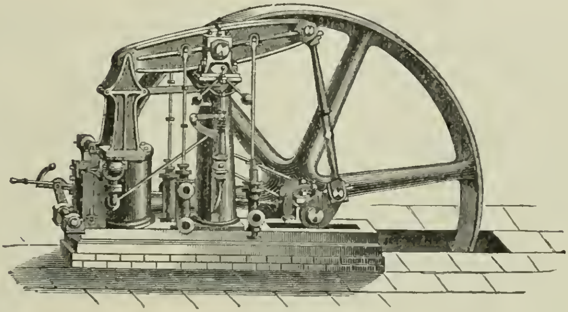


Fig. 2.

Figure 2 shows a finished woodcut from the same sketch, and can be pronounced satisfactory from either the pictorial or mechanical standpoint.

The sketch Fig. 1 was made in less than $2\frac{1}{2}$ hours time from a working drawing, which showed a front elevation, two end views, and a plan, all drawn to the scale of $1\frac{1}{2}$ inches to the foot, or one-eighth full size. The front dimensions were all taken by a pair of proportional compasses, set at one to six, and the end and top dimensions by reducing one to six *twice over.* The scale of the figure is consequently one forty-eighth on the front; and one two-hundred-and-eighty-eighth at the end and top. Of course all the lines in horizontal planes at right angles to the front (in the machine itself, or its working drawing), are inclined 45° to the horizontal or vertical lines in the face of the Fig. 1, and any length measured on those diagonal lines is a little more than *one-fourth* the front scale, (the true scale of end or top dimensions consequently becomes one two-hundred-and-fourth part in place of one two-hundred-and-eighty-eighth.)

The example chosen to illustrate here is purposely that of a large object, the natural size being over 8 feet high by 15 feet long. If the style of drawing suffices for such a picture, and without painful distortion, and the scale is practically preserved, it is apparent that for smaller objects its suitability is demonstrated.

The system was introduced in illustrating a catalogue nearly fourteen years since, the writer supplying the outline drawings for several sheets of objects, and the artist who completed them has since adopted the same style with much success. And from the facility it affords for making a scale picture from a set of bare working drawings, it is thought it merits publication at this time.

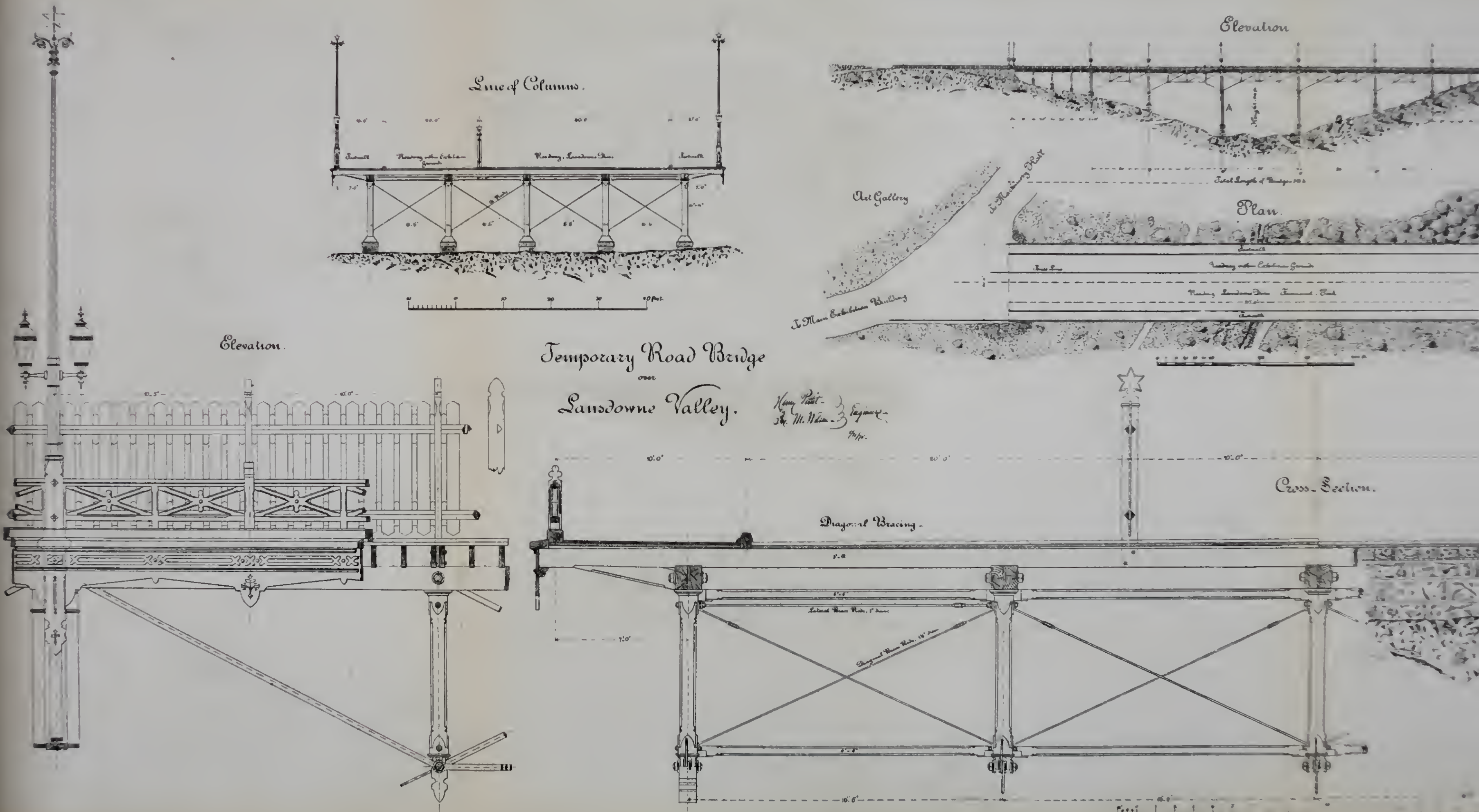
Bibliographical Notice.

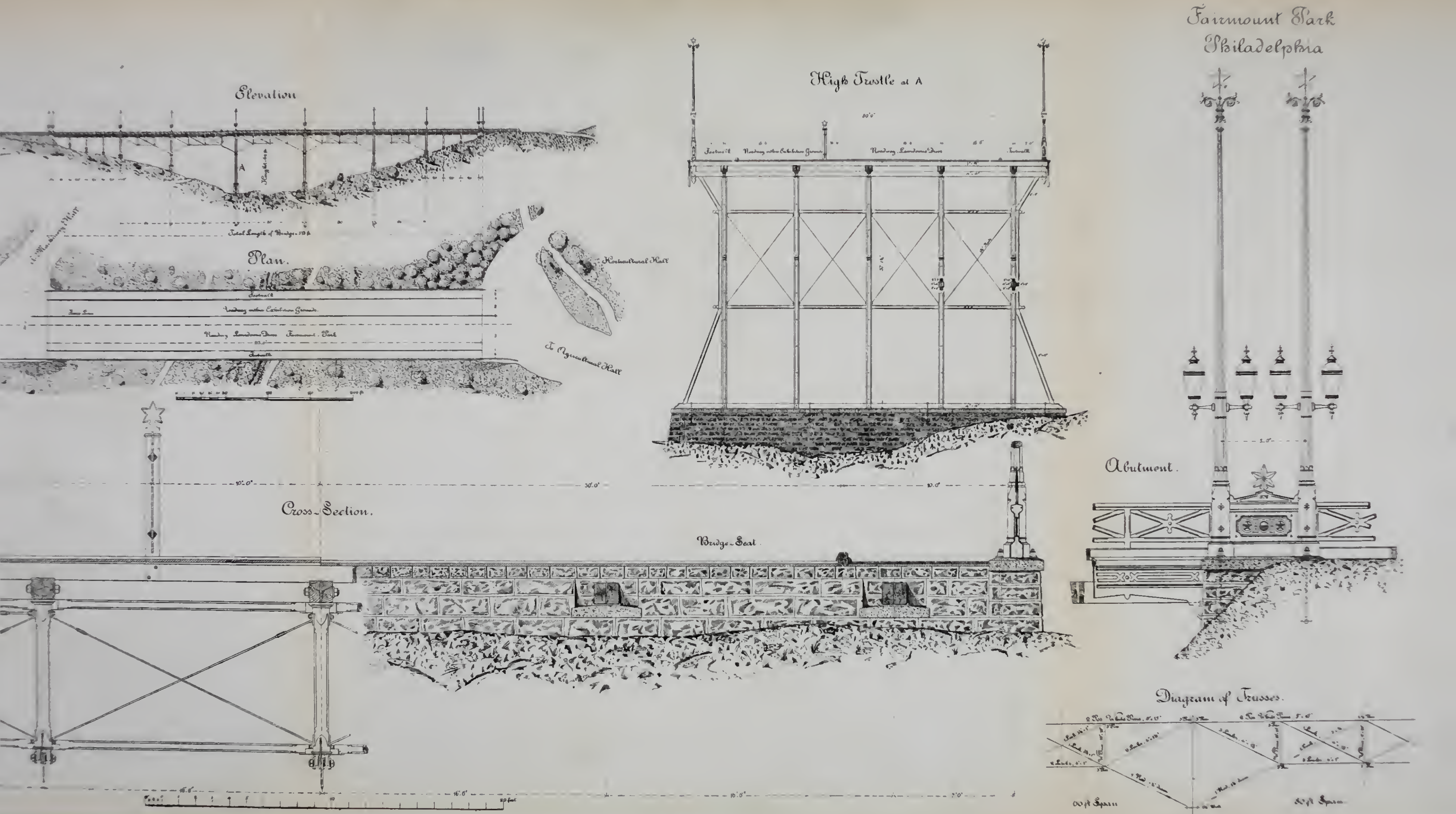
THE ELEMENTS OF GRAPHICAL STATICS. By A. Jay Du Bois, Prof. C. & M. Engineering, Lehigh University, Pa. 1 vol., Text and Atlas, 2 vols., 8vo. John Wiley & Son, New York.

This work is a full university course of instruction in the graphical method, combined with algebraical analyses of applied mechanics, applied to structures of all kinds; from which the advanced student will have derived such instruction as will be of extreme value in the practice of engineering. The grouping of all the separate examples of graphical methods of the French geometers and mathematicians of the past half century, the application of some isolated problems of descriptive geometry, and the forming of a separate branch of study has been well effected with German thoroughness, and is attributed, in the translated introduction by Dr. J. J. Weyrauch, of Stuttgard, to Prof. K. Culmann, of Zurich. The introduction of Doctor Weyrauch possesses the highest value as a historical sketch, although somewhat partisan in its nationality. It follows the course of one branch of mathematical inquiry, with an evidence of great research and knowledge, and gives an account of the bibliography of applied and descriptive geometry not elsewhere to be found. The scope or readiness of application, and ease of comprehension or study of Culmann's works are not known to us, but we can affirm that the graphical method, is set forth in Prof. Du Bois' work with singular simplicity, and is accompanied by supplemental chapters of analysis with examples for discussion in excellent demonstration. The importance of the graphical method in considering the strength of engineering works can scarcely be overstated; not that it is more easy of application to the problem, or more accurate in final result, for it is in fact only a linear expression of quantities and forces, exhibited in two dimensions, which quantities and forces would otherwise be expressed in figures or algebraic terms, but that its *tangibility* both of process and in completed diagram, is peculiarly satisfactory and devoid of accidental, unavoidable errors. It is a kind of knowledge which once acquired is never lost to the mind, but is at all times afterward available for current use. The neglect of geometry in the studies of our technical schools has been quite marked, and has proceeded principally from the absence of practical application. With this hand book of applied geometry, this branch of mathematical science will be restored to the classes of students in engineering. The work has been published in a superior manner, well suited for its purpose, and although plates in the text would have improved its value to the engineer, after completion of his studies, the atlas of mounted plates is preferable for pupil; and the adoption of the book as a text book in technological schools cannot be too highly recommended.

International Exhibition

1876.




Fairmount Park
Philadelphia
Elevation
Plan.
Horticultural Hall
To Agricultural Hall
High Trestle at A
Footwalk
Roadway within Exhibition Grounds
Roadway Lansdowne Drive
Cross-Section.
Bridge-Seat
Abutment.
Diagram of Trusses.

Civil and Mechanical Engineering.

ROAD BRIDGE OVER LANSDOWNE VALLEY, FAIRMOUNT PARK, PHILADELPHIA.

By Joseph M. Wilson, C.E.

In laying out and arranging the grounds which were appropriated by the Commissioners of Fairmount Park for the use of the United States International Centennial Exhibition, it was found advisable to construct a road bridge over the Lansdowne Valley, a deep ravine just north of the Memorial Hall. The plans were accordingly prepared by Mr. Henry Pettit and myself, as joint engineers and architects to the Centennial Board of Finance, and the erection is now proceeding under our direction, the contractors being the Watson Manufacturing Co., of Paterson, New Jersey.

The following description and accompanying plan are presented in the hope that they may prove of interest. The bridge consists of twelve spans, the general dimensions being as follows:

3 Centre Spans, 80 feet each, . . .	240 feet.
2 Intermediate Spans, 60 feet each, . .	120 "
7 End Spans, 20 feet each, . . .	140 "
6 Spaces over Piers, 10 inches each, . .	5 "
2 Spaces over Abutments, 5 feet each, . .	10 "
Total Length of Superstructure, . .	515 "
Approach Wall, north end, . . .	45 "
" " south " . . .	125 "
Extreme Length of Railing on Bridge and Approaches, ...	685 "
Width of Roadway, ...	60 "
Width of Foot-walks, 10 feet each, . .	20 "
Total Width of Bridge, ...	80 "
Distance centre to centre of trusses in the same span,	15 "
Projection of Foot-walks beyond Trusses, .	$7\frac{1}{2}$ "

The spans of 60 and 80 feet consist of single intersection, deck, Pratt trusses with timber upper chords and posts, and wrought iron lower chords and other tension members, vertical diagonal bracing

being introduced between each of the posts in the trusses, and upper lateral bracing between the upper chords of the two outer trusses only, and continued to the abutments at each end. The foundations are of masonry throughout, trestles of timber being erected on the piers. The trestles are framed with combination posts, the pieces firmly bolted and mortised together, forming a stiff rigid system, and vertical diagonal bracing is placed between each of the posts.

Wind ties are introduced, connecting the lower chords of the truss spans with the trestle, those on the outer ends of the 60 feet spans being firmly bolted to the masonry.

The masonry is of the best Conshohocken stone, that in the foundation work being laid with good flat beds, the stone of good size and shape, none averaging less than six cubic feet, and the footing courses projecting 6 inches on all sides. The masonry above ground is rock range work pointed with dark mortar. The coping and cap stones are of Newark sandstone, hammer dressed, with sloping top, and draft on the faces, laid in cement. The lower courses of foundation work for three feet in height, under the trestles and pier columns, are laid in cement; the balance of the work is in strong lime mortar.

The wrought iron work is specified of the best quality, all that in tensile members, viz., carrying links, lower chords, counters, lateral and diagonal braces, wind ties and bolts, of double rolled iron from the muck-bar, and capable of withstanding, on a turned down or grooved section, a tensile stress of 60,000 lbs. per square inch; the links when tested to the breaking strain, if so required by the engineers, to part through the body and not at the head. All joints to be made tight by thickening washers whenever necessary; pins to fit the holes within one-hundredth of their diameter, and sleeve nuts to be introduced in the counter links.

The bearings at top and bottom of posts and on trestles and the finish to hand-rail over abutments are to be of cast iron.

All of the lumber throughout the structure, except where otherwise specified, is of the first quality white pine, free from flaws, shakes, unsound knots, and in every way suitable for the various purposes for which it is intended. The floor beams are of three by twelve inches section, placed 16 inches apart, between centres. The flooring on roadway consists of two thicknesses of two inch plank, the lower layer being of white pine, laid diagonally, and the upper of white oak laid at right angles to the line of travel. The flooring on foot-

walks is also in two thicknesses, the lower layer being two inch white pine, and the upper layer one and a quarter inch yellow pine, tongued and grooved and laid longitudinally to the structure, no boards being allowed over six inches in width. The curb is of white oak.

All the lumber forming the trestles, columns, truss posts, upper chords, and lateral struts throughout the structure is dressed. All parts of the bridge except the flooring and floor joist, are to be painted in three coats in oil of approved tints; the under side of flooring and floor joist to be kalsomined in two coats.

Tin conductors, 3 by 4 inches section, and 3 feet long, are introduced in the flooring next to curb, at the centre of each panel in the roadway, and at 40 feet distances in the foot-walks.

The bridge will no doubt be a favorite resort; commanding a very fine view up the river, and of the ravine beneath it, the floor at the centre being 68 feet above the ground.

VERTICAL BLOWING ENGINES.—THE INTRODUCTION OF VERTICAL BLOWING ENGINES INTO CLEVELAND.*

By Mr. John Gjers, Middlesbrough.

[From *Engineering*, London, October 29, 1875.]

Those conversant with blast furnace plant, will probably remember, that, prior to about 1850, the most prevalent type of blowing engine was the old-fashioned beam engine, of long stroke, varying from 8 feet to 12 feet, and air-flaps arranged on the top and bottom covers, made of strong double leather, sewed together, stiffened with an iron plate riveted on the back. Such engines were made of large size, usually one engine for the whole set of furnaces connected with one plant; such, for instance, as the, at one time, famous engine at the Ebbw Vale Works, with a blowing cylinder of 12 ft. diameter and 12 ft. stroke.

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* Paper read before the Cleveland Institution of Engineers.

These ponderous beam engines are necessarily of a very expensive construction; the foundations required are of great magnitude, and the whole system is open to the objection that a single disarrangement or breakdown suspends the operation of the whole plant. The large heavy flaps, closing and opening over large ports, are a constant source of anxiety, and difficult to keep in order.

Another type of engine had, to some extent at that time, also been introduced, viz.: the horizontal arrangement—like the beam engine with a long stroke—capable, like it, of running at the slow speed of only about twenty strokes per minute. But the same objectionable heavy flaps, arranged on each cover, stuck to this system, and these engines, as a rule, were not even so satisfactory as the beam engine.

About this period began a general movement among engineers to introduce steam machinery of a direct-acting kind. Engines of short stroke to work at high speed, began to be introduced for stationary purposes, and by some it was thought that this system could be applied with advantage to blowing engines. But the heavy, unmanageable air-flap valves seemed to be an obstacle which would ever prevent blowing engines being run at a high speed.

Foremost among these early workers, as regards blowing engines, was Mr. Archibald Slate, a member of the firm of Messrs. Cochrane and Company, of the Woodside Iron Works, near Dudley, a man of great energy and much inventive talent. He, about 1852, took out a patent for the direct-acting, short stroke, high speed blowing engine, well known by his name; and he was the first to introduce the system of sub-dividing blowing engines, for a plant of furnaces, to something like an engine per furnace. Slate, in his engine, discarded altogether the then, for high speeds, unmanageable flap valve, and introduced an annular casing round the blowing cylinder, working over ports, and actuated from the crankshaft on the principle of the slide valve, opening the ports alternately to the external atmosphere for a supply of air, and to the interior of the casing for the exit of the compressed air. From this casing the compressed air was transferred to the blast tube by means of a sliding face.

These engines, on a large scale, were first introduced at the Ormesby Iron Works, which Messrs. Cochrane and Company erected in 1854. Four horizontally arranged engines, with 50-in. blowing cylinders, and 2 ft. 6 in. stroke, intended to run from 70 to 80 strokes per minute, were put up to blow the four original furnaces. These

engines were sufficiently successful to encourage Mr. Slate to follow them up, but it was felt, for sundry reasons, such as the wear and tear upon the heavy casings, and the difficulty to efficiently lubricate the same, that a vertical arrangement was more desirable, and consequently he designed such an arrangement, and the first pair of Slate's vertical engines were put up by Mr. Edgar Gilkes, at the Tees Iron Works, Messrs. Gilkes, Wilson, Pease and Company. This, then, was the first vertical blowing engine of the direct-acting, short stroke, quick speed kind.

In 1858, when Messrs. Jones, Dunning, and Company were about to erect the Normanby Iron Works, Mr. Edwin Jones, in conjunction with Mr. Richard Howson, designed a somewhat superior arrangement with the steam cylinder at the top, and the blowing cylinder below, and also introduced the improvement of balancing the weight of the casing, and this formed the model for a number of such engines being made. (See Figs. 1a, 1b and 1c, of engraving.) In 1863, Mr. Howson and Mr. Jones introduced some further improvements, with a view of doing away with the objectionable sliding face necessary to transfer the blast from the casing to the blast tube, and subsequently such engines were erected both at a new extension of the Normanby Works, and at Messrs. Samuelson and Company's Newport Iron Works, in 1864. (See Figs. 2a and 2b.)

Previous to this, in 1863, the author of this paper was engaged by Messrs. Lloyd and Company to design the Linthorpe Iron Works, and the question of what kind of blowing engine to be adopted became one of considerable importance. The beam engine was objectionable on account of difficult and treacherous foundations. Slate's engine had to some extent been successful; still there was much to be desired. The casings were not free from a certain amount of loss from leakage, the amount of lubrication necessary was large, and a considerable noise and thud at the opening of the ports was difficult to overcome. It was impossible to arrange the inside lap of the casing so as to meet the requirements of varying pressures of blast, consequently, in practice very little lap was given—hence there was a loss of power from the pressure coming back upon the piston from the casing, before the pressure had sufficiently accumulated in the cylinder. It was also strongly felt by the author, that there was no sufficient reasons why a suitable self-acting flap should not be designed to meet the necessity of the case. The kind of engine, viz., the

short stroke vertical direct-acting one, was determined upon, and such a design of flap valve and grid was produced (see Fig. 3c), which was believed would answer. In conjunction with Mr. Howson, then manager for Mr. John Stevenson, of Canal Foundry, Preston, the engine was designed somewhat on the general arrangement of the Normanby Slate engine, as far as the steam engine part was concerned; but the blowing part of the arrangement was of an entirely novel and hitherto untried construction. (See Figs. 3a and 3b of engraving.)

Four such engines of power sufficient for three engines at a time to blow the four furnaces, were put up and proved without the slightest alteration entirely satisfactory, and continue in work to the present day. One other novelty was introduced in these engines, and it will be seen by the drawing that the suction flaps are not open to the atmosphere of the engine house, as was always usual up to that time, but that on the contrary all the suction flaps as well as the delivery flaps are enclosed in casings, and that the engine thus sucks its supply of air from one tube, and delivers the compressed air into the blast tube on the opposite side, the intention of this being to prevent the rattle of doors and windows, caused by the concussion of the air inside the engine house, and also to avoid the dust and dirt being drawn into the house; a further object being to enable the supply of air to be taken and dealt with as desired from any convenient spot outside. It has also another very desirable effect, namely, it apparently steadies the working of the engine, and causes an actually superior supply of air to the suction flaps, the moment they open at the change of each stroke. This will be better understood if we consider the case of an engine taking its supply direct from the atmosphere; when the suction flaps are closed the air outside is perfectly stationary, and at every change of stroke the air outside has constantly to be started and stopped in its motion. With the suction tube, on the contrary, the whole volume in the tube acquires a nearly constant motion and speed, the momentum of which completely fills each cylinder as it cushions up against the piston, as it slackens its speed towards the end of each stroke. This can be distinctly felt through any small hole in the casing, as an actual puff out of air at the end of each stroke, and amounts in the Ayresome engine suction casing to a water gauge pressure of 4 in. or 5 in., followed by an about similar amount of suction, making altogether a water pressure difference of 9 in. or 10 in. These Linthorpe engines

were thus the first and original short stroke vertical direct-acting blowing engines, working with self-acting flap valves, sucking their air from one tube, and delivering into another, and they have been the type of the whole crop of engines of this class, which have since been made in this and other countries, and the best proof of the favor this class of engines has met with, is the fact that no more Slate's engines have been made since about this date, 1865.

About the end of 1865, Messrs. Stevenson, Jacques, and Company, started their Acklam Iron Works with a new kind of vertical blowing engine of short stroke, arranged with large sliding valves on the top and bottom covers for the ingress and egress of the air. This proved a complete failure, and the engine was altered as well as circumstances would allow by Messrs. Kitsons, of Leeds, and suction flaps on the principle of the Linthorpe ones were placed all round the top and bottom of the cylinder, and similar delivery flaps placed in the original casings on the top and bottom covers. These engines have continued to work satisfactorily ever since, and may thus be said, in their altered state, to be the second example of engine of this type, with the exception that the suction flaps draw their supply of air direct from the atmosphere.

The Tees-side engines of Messrs. Hopkins, Gilkes, and Company, came next; they were arranged by the author, and carried out at the Canal Foundry, Preston, under the superintendence of Mr. Howson. These engines only differ from the Linthorpe ones in having larger cylinders, consequently it was thought advisable to place the valve grids at an angle, as shown, so as to get more room and reduced length of ports; three tiers of flaps on one grid, were also arranged as shown. Three of these engines were arranged to supply blast for two furnaces. (See Figs. 4a to 4e of engraving.)

Another example of the original class of engine arranged by the author, and carried out by Mr. John Stevenson, Preston, is shown in Figs. 5a to 5d of the engraving. This illustrates a further step in the improvement of these engines, whereas in all previous examples, floorings connecting the engine with the walls of the house had been thought indispensable. In these engines no such flooring was provided, but the engine left standing free, entirely independent of the house. A staging was simply provided at the top of casings connecting the engines, and accessible by a spiral staircase, a fur-

ther small staging to get at the steam cylinder top cover, and one to get at the motion bars was also provided, as shown, and these engines have proved most satisfactory in every respect.

In 1866, Mr. Charles Cochrane, after carefully examining the working of the Linthorpe engine, was so well satisfied of their efficiency, that he determined upon replacing his original Slate's engines at Ormesby Works, with engines of this kind; and under the superintendence of Mr. Downey, two engines were made by Messrs. Cochrane, Grove and Company, from patterns designed by themselves, embodying the principles of the Linthorpe engine; and an engine was produced similar to the drawing showing the "Ayresome" engine, except that instead of being entirely independent, it had floorings at the bottom and top of casings from the engine to the walls of the house, and the stroke being 4 ft. 6 in. instead of 4 ft. In this case the cylinder being the large size of 100 in., it was impracticable to adopt the cast iron casings, and a wrought iron casing was adopted as shown. To get sufficient grid area the flaps were arranged in four tiers and the valve boxes somewhat differently arranged as shown. This large engine proved so satisfactory that Messrs. Cochrane, Grove, and Company afterwards continued for some years to reproduce the same for various other works.

Another modification of the same principle of engine was arranged by the author for the West Yorkshire Iron Company at Ardsley*, near Leeds, and was carried out by Messrs. Cochrane, Grove, and Company, under the superintendence of Mr. Downey. In this case the blowing cylinder was placed at the top, and the steam cylinder below a crosshead working in motion bars between the cylinders, carrying the connecting rods on each side of the steam cylinder to take hold of crank pins on the flywheels. The stroke is 5 ft., the total height of the engine being no more than the 4 ft. stroke engine on the original arrangement. The air flap and casing arrangement is similar to the previously described engine. This general arrangement of engine was the first of its kind, and has been reproduced for several other works, amongst others, by Messrs. Westray and Forster, of Barrow, for the Lofthouse Iron Company.

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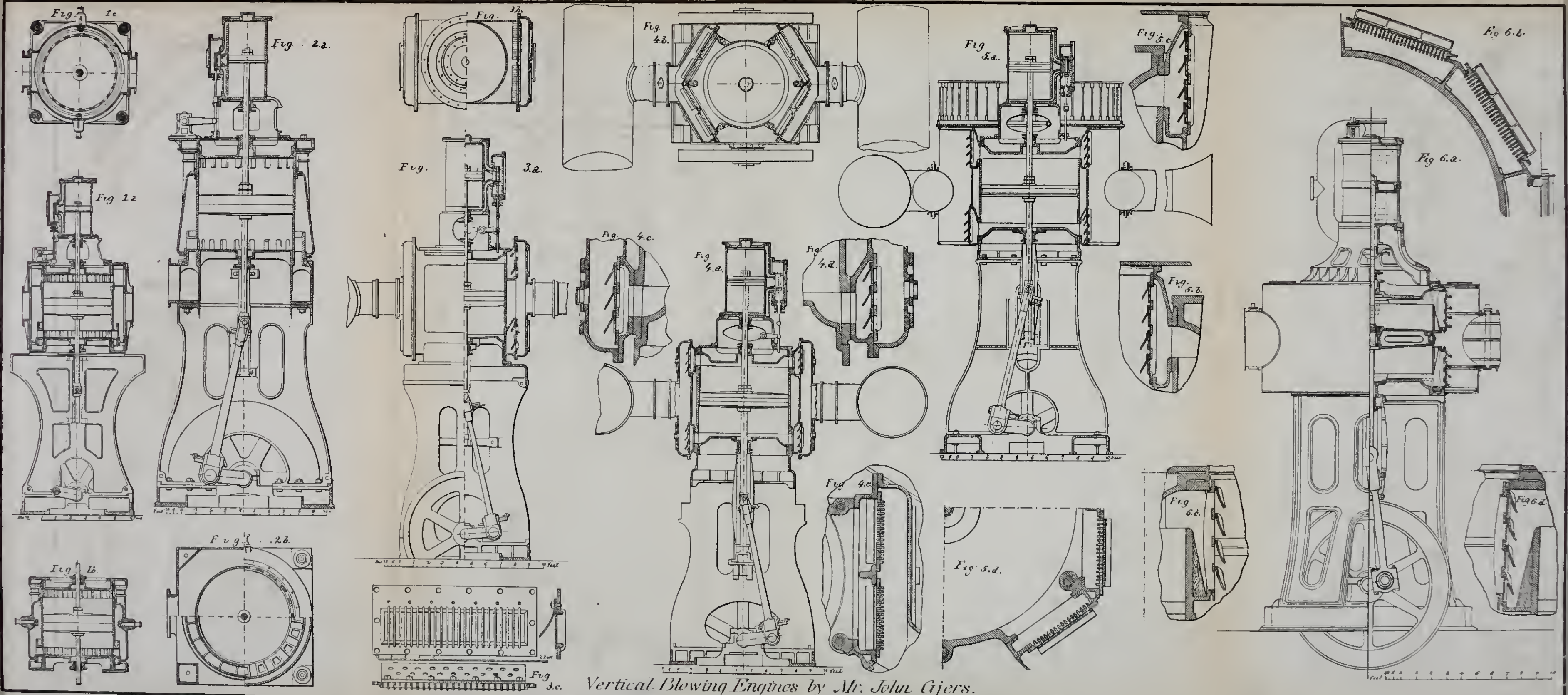
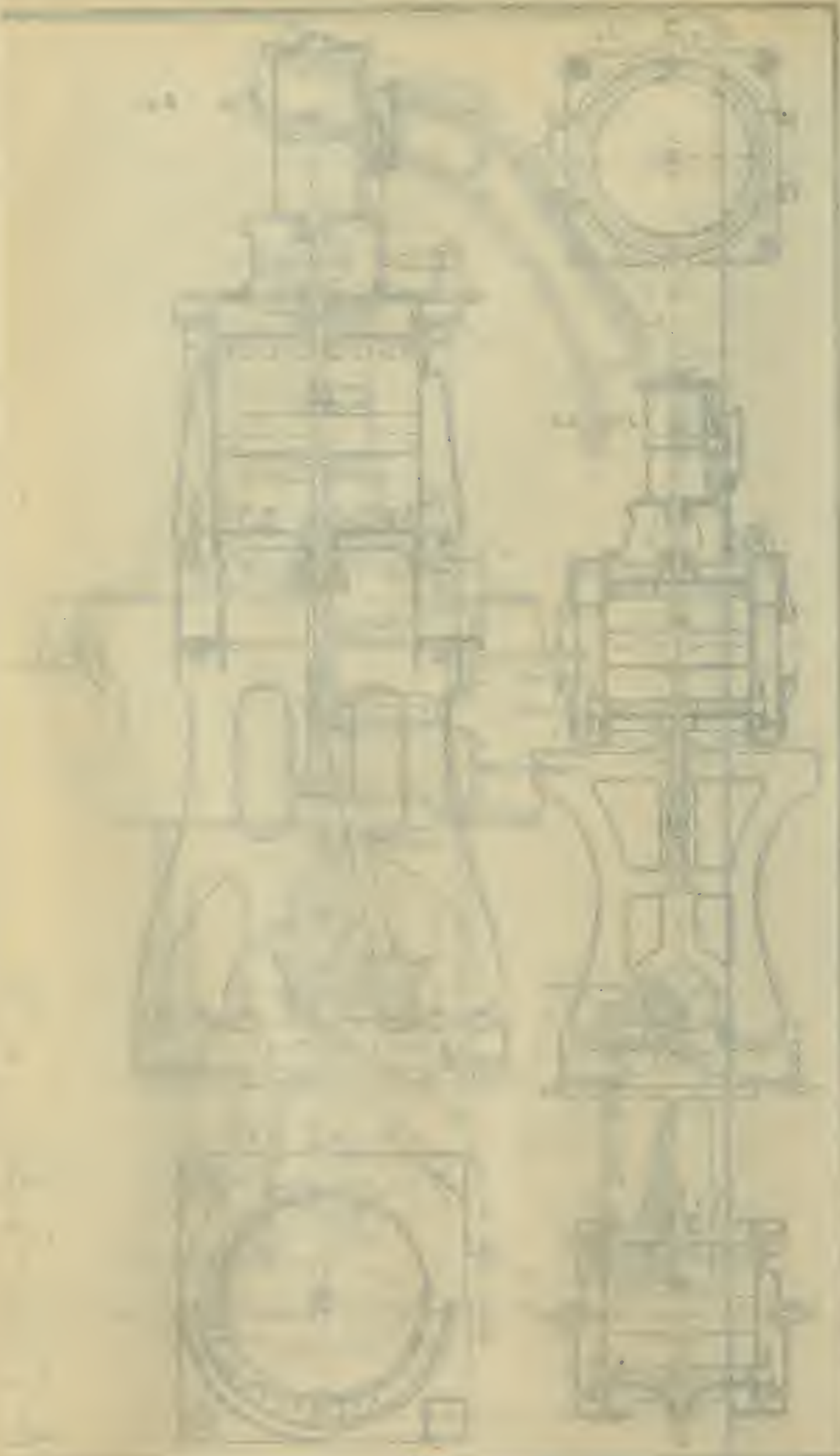
* A two-page engraving of these engines was published in *Engineering* for March 4, 1870.



Vertical Blowing Engines by Mr. John Gjers.



In 1870, when the author had occasion to erect the Ayresome Iron Works for himself and partners, three large engines, two of which should be sufficient to blow four furnaces, were decided upon, and were carried out by Messrs. Cochrane, Grove, and Company, under the superintendence of Mr. Downey. The engines are generally similar to those originally made for the Ormesby Iron Works, except that the stroke was reduced to 4 ft., and the blowing cylinder to 96 in., the steam cylinder being 40 in. A piston valve was also adopted for the distribution of steam in place of the ordinary slide. These engines were similarly arranged to the Frodingham ones, standing entirely free with simple stagings as before described, as shown, and have been most entirely satisfactory. (See Figs. 6a to 6d.)

The peculiarity of the above engines, and in what they differed from the old beam and horizontal kinds is, as will be noticed, a vertical direct-acting short stroke; this they have in common with the earlier kind patented by Slate, and improved by Jones and Howson; but the further peculiarity, and the one which has made them successful in superseding Slate's and other engines—was originated by the author, and carried out in varied detail by Mr. Howson, Mr. Downey, Mr. John C. Stevenson, and himself—consisted in the introduction of a light air-flap, capable of working at any speed, arranged around the top and bottom sides of the cylinder, and enclosed in casings, the suction flaps on one side and the delivery flaps on the other, taking the supply of air from one tube and delivering it into another.

The author believes he is right in stating, that the engines illustrated above are the type of a large class (more or less embodying these principles), now made in various parts of the world, and claiming Cleveland as their birthplace. The class of engine described above have many important advantages over the old beam engine; the first cost is considerably less, they stand in much less room, the cost of the foundation and house is also much less—it may be taken, putting these items together, that the first cost, to blow the same quantity of blast, is not much more than one-half, while maintenance and repairs, blast for blast, is about the same.

But, say the opponents of these engines, there must be a great loss in the short stroke; the compressed air which fills the clearance at the end of each stroke must be lost. The answer is, that running

double the number of strokes, the amount of clearance practically being the same, it is evident that whatsoever the loss (if loss there be) in the 8 ft. stroke, it is doubled in the 4 ft. stroke. It is, however, certain that the amount of such loss in the ordinary pressure blast engine is generally greatly over-estimated, and when it is said, as is often maintained by practical men, that the loss in each stroke is the cube contents of compressed air in the clearance, then it is an error, and one which, if the author can help to dispel, he will feel justified in having taken up your time with this otherwise not very interesting paper.

Referring to Figs. 7a to 7c, to illustrate the theoretical action of the compression of air in a cylinder, and the effect of clearance, and taking the law of Mariotte, that "at constant temperatures the pressure is inversely as the volume," it is clear that in Fig. 7a, which represents a supposed cylinder of 5 ft. stroke, with absolutely no clearance, the air, for example's sake, to be compressed to $3\frac{3}{4}$ lb. above the atmosphere (which is an average blast pressure), and an atmosphere in round numbers to be taken at 15 lb., then $15 + 3\frac{3}{4} = 18\frac{3}{4}$, and 15 to $18\frac{3}{4}$ = 5 vol. to 4 vol.; or in other words for the pressure to increase by one-fourth, the piston would have to travel 1 ft., or reduce the volume by one-fifth, the pressure curve described would be hyperbolic, and with a supposed constant temperature the indicator diagram would be as shown by A B C D. (See Fig. 7a.)

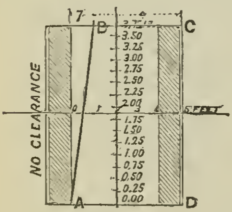


Fig. 7a.

Again, to show the effect of extreme clearance space, say the stroke the same as before, what would be the amount of clearance space measuring for absolutely no blast to be expelled from the cylinder? Supposing constant temperature as before, evidently it would require a clearance represented by 20 ft. of spare cylinder at each end, as it would require the piston to travel 5 ft., or reduce the volume by one-fifth to increase the pressure by one-fourth, that is to bring up the pressure to $3\frac{3}{4}$ lb., in this case the indicator diagram would be simply the curve line E, F, backwards and forwards, enclosing no space, expelling no blast, and representing no power lost. (See Fig. 7b.)

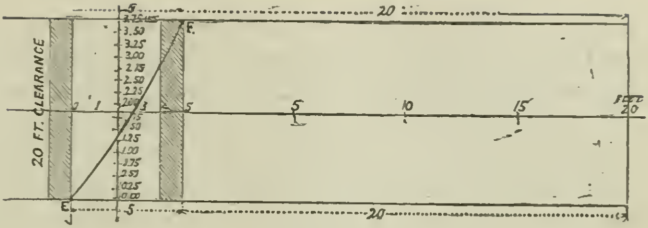


Fig. 7b.

In the same way, it is clear, that if we take the case of a cylinder clearance more nearly approximated in actual practice (see Fig. 26), the same 5 ft. stroke, but a clearance space at each end, equal to a cylinder extension of 5 in., then as before, to increase the pressure, by one-fourth, or to $3\frac{3}{4}$ lb., it would require the piston to travel 13 in. or reduce the volume by one-fifth; and similarly in coming to the end of the stroke and traveling back, the piston would have to travel $1\frac{1}{4}$ in. or one-fourth of the 5 in. clearance space before the compressed air in that space had expanded down to atmospheric pressure, or from $18\frac{3}{4}$ lb. to 15 lb. The diagram lines would be G, H, I, K, in Fig. 7c.

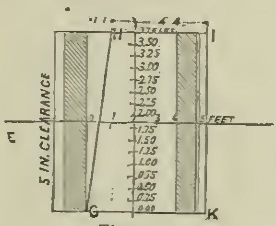


Fig. 7c.

It will thus be seen, with these supposed circumstances, that the diagram proves the loss due to the clearance space to be equal to only $1\frac{1}{4}$ in. of the travel, or in other words, the actual loss in blowing capacity, at the above pressure, is only one-fourth of the total clearance contents, and not the whole of it, as has erroneously been taken for granted by many practical men. This can be illustrated in another way without the aid of the diagram. It is clear that an engine with a cylinder similar to Fig. 7c would suck in air during $58\frac{3}{4}$ in. of its stroke, whereas, with actually no clearance, it would suck it in during the whole 60 in. of the stroke, and what is taken in must be given out again.

To apply the above to the actual case of the Ayresome engine, the author begs to refer to diagram Fig. 8a. The pressure actually blown at these works is $4\frac{1}{2}$ lb., and the stroke 4 ft., the total clearance space is equal to a cylinder extension of something more than 7 in., but call it 8 in., the theoretical indicator diagram on this data is A, B, C, D, showing a loss of blowing capacity due to the clearance equal to $2\frac{1}{3}$ in.

A number of actual indicator diagrams have been taken, one of which is shown by the thick line on Fig. 8a. It will be seen that the actual diagram shows considerable less loss or only about $\frac{7}{8}$ in. of the stroke. It arises from this, and is one further reason why a moderate clearance space is so objectionable. That, as before stated, the theoretical curve laid down to illustrate the principle is the hyperbolic curve of constant temperature, whereas the actual curve got in practice, nearly assimilates to the adiabatic curve of no heat being abstracted in compression or given out in expansion. Now, you are well aware that when air is compressed in the cylinder the temperature increases considerably, and consequently, as shown by the actual diagram, the pressure increases faster than the volume diminishes, and in the same way the compressed air in the clearance space is brought much quicker down to the atmospheric pressure in consequence of the cooling action in being expanded. The loss then in the Ayresome engine is shown by the actual indicator diagrams to be about $\frac{7}{8}$ in., or one-fifty-fifth part of the stroke, but it is not even correct to call this a loss of power, as the diagram truly represents the power expended in compressing the air which is actually delivered. In reality, the power expended in compressing the air in the clearance space is given back again by that air expanding at the return of each stroke, consequently it is not loss of power, simply loss of capacity for blowing, which, if a 4 ft. stroke engine is compared to a 8 ft. stroke, may amount to say one per cent. less. To compensate for this, it is only necessary to keep the 4 ft. stroke engine at one per cent. higher piston velocity, or make it one per cent. larger piston area—no more steam being consumed—taking no account of the little extra friction. The author entertains the hope that the above has made this truth clear, that within ordinary limits the power required to compress say 1000 cubic feet of air to the ordinary blast furnace pressure is practically independent of what the stroke may be, and that the objections raised against the short stroke blowing engine, have been proved to be as unfounded in theory as they are in practice.

A moderate clearance space in blowing engines for blast furnace purposes is practically considered not objectionable, as the easier working of the flap valves, and steadier working of the engine is thereby facilitated; the author hopes, therefore, also to have proved that within reasonable limits the clearance space is not objectionable, either from a practical or from a theoretical point of view.

The author begs also to point to the actual good work these engines are admittedly doing, as compared with long stroke beam engines of the same calculated capacity, as a further proof that there can be nothing seriously wrong either in the short stroke, nor in any little extra clearance space there may be. A number of indicator diagrams have been taken by the ordinary 10 lb. spring, which show a very perfect working of the blast cylinder in the Ayresome engines.

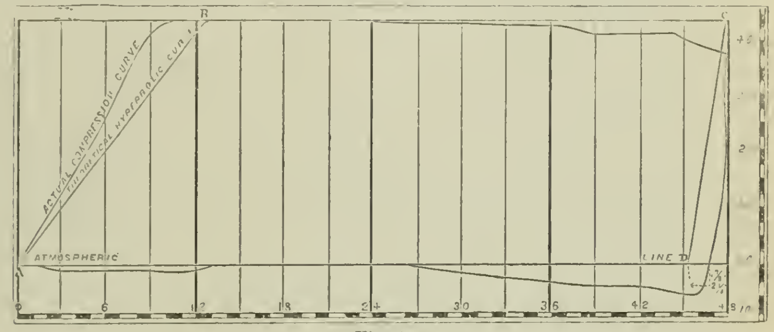


Fig. 8a.

To exhibit this on a larger scale, the author had a 5 lb. spring made, and the diagram Fig. 8a, is from one of those. It is feared, however, that on the suction side, the indicator piston has bobbed the light spring beyond the mark, as the other diagram, taken with the stronger spring, does not point to any unusual suction at the beginning of the stroke.

Table giving Principal Dimensions of the Blowing Engines, illustrated in connection with Mr. Gjers' Paper.

Works at which the Engines are working.	Diameter of Steam Cylinder.	Diameter of Blowing Cylinder.	Stroke.	Ratio of Area thro' Valves to Pist'n Area	Speed in Rev'ltions per Minute	Cubic Feet of Air delivered per Minute.	Reference to Figures on Engraving.
	in.	in.	ft. in.		rev.	cub. ft.	
Normanby.........	21	56	3 0	1 : 4	40	4,100	Figs. 1a to 1c
Newport............	31	79	4 8	1 : 5	40	12,700	Figs. 2a & 2b
Linthorpe.........	30	66	4 0	1 : 8	40	7,600	Figs. 3a to 3c
Tees-side....	32	72	4 0	1 : 8	40	9,040	Figs. 4a to 4c
Ardsley............	32	72	5 0	1 : 5	40	11,300	
Frodingham......	34	78	4 0	1 : 7	40	106,000	Figs. 5a to 5c
Ayresome.........	40	96	4 0	1 : 5	40	160,000	Figs. 6a to 6d

AMERICAN RAILWAY CARS.*

On the afternoon of Saturday last, the limited express by the Pennsylvania Railroad, from Philadelphia, due here at 2·26 P.M., met with an accident which served to show very clearly the excellence of American car building practice. It was thrown from the track about two miles east of the city of Trenton, and, so far as could be judged from the appearance of the track and switch, the accident was caused by a broken switch stand. The engine passed over safely, but displaced the rails so that the tender jumped the track, dragging after it the mail, baggage, and two of the drawing room cars. Crossing one or two tracks, the cars struck a coal train standing on a side track, and demolished a number of the coal cars, at the same time ripping up and completely wrecking the tracks over which they passed. The road bed itself was damaged considerably, being dug up, and ties cut and torn out, so that it was necessary to lay tracks around the break. The force of the blow was so severe that the ends of both the baggage and mail cars were completely crushed and shivered. Neither mail agent nor express agent in these cars received any injury, however. The two palace cars following, which left the track, were uninjured, save that one of them had a platform broken; the car itself, however, was intact. The coal cars which were struck by the train were completely demolished. The tender, which was wrenched from the engine by the shock, was also destroyed. The distance run was very short, as the engineer put on the brakes before the tender went down. The time in which the power had to act was of course very short, but as the parting of the couplings does not throw the brakes off, they continued their effect until the train stopped. The train was a fast one, and running at a high rate of speed (not much under the rate of forty miles per hour at the time), and with the exception of the baggage and mail cars, it was made up of heavy Pullman drawing room cars. The weight of that part of the train that left the track, with that which did not, could not have been less than 460,000 pounds. Great surprise has been expressed that no one was hurt, and that so little injury was done to

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* From the *Iron Age*, N. Y., Nov. 18, 1875.

the train. When the construction of these cars is considered, it is nothing to be surprised at, their behavior under the circumstances being what would be expected. The tender, being short, heavily loaded, and by no means as strongly built as a passenger car, was destroyed. Those cars that struck the coal train and rolled loose from their trucks, had their ends broken in, while in the last cars the shock was very light; passengers remarked: "that is a very short stop;" but it was not supposed that an accident had happened. In the cars of this pattern, the amount of resistance offered by the framing is something enormous. Six sills are commonly used, beside two truss planks or their equivalents. In many cases, even more timber than this is put in. The cross section may, we think, be safely set down as about 240 square inches of the best Southern pine, whose crushing stress cannot be less than 6000 pounds per square inch, or a total of 1,440,000 pounds. In the baggage and mail cars the quantity of timber is even greater, since they are framed so as to carry heavier loads. To crush in the end of a car thus framed, as might be expected, is exceedingly difficult, as the blow comes upon the platform, and its force is seriously diminished before it reaches the car body. With a train of cars less strongly framed, the forward ones must certainly have been crushed or telescoped, and the resulting loss of life, would, of necessity, have been heavy. Recent accidents in England, of a very similar character to this one but with trains, so far as we can learn, weighing much less, have resulted in large losses of life. The side doors necessary in compartment cars of the kind used there, are doubtless very convenient at stations, but when, through those same doors, the passenger shot out into a mass of debris during an accident, finds himself a part of the general wreck, and is crushed and ground among springs, wheels, sole-plates and panels, he would, it is safe to assert, willingly exchange the convenience, for more strength and safety. We say confidently that we do not believe it is possible to build cars with compartments and side doors that can in any way approach the strength of the long American car with end doors. The whole floor and side as far as the window sills, is a unit, and the amount of resistance which is offered is something extraordinary, when compared with the coaches used on foreign railroads.

MILL LIGHTING BY ELECTRICITY.*

By A. Tolhausen.

In spite of the many improvements which have been brought to bear on the various magneto-electrical machines for the generation of light, the use of electricity for lighting up mills or other workshops, in place of common oil or gas, has scarcely been introduced.

The "*Journal für Gasbeleuchtung*," however, recently observes that in the establishment of Messrs. Heilmann, Ducommon & Steinlein, in Mühlhausen, electricity has been applied apparently with success, for lighting-up purposes. In a separate room, four magneto-electrical machines are placed, which feed other four suitably located lamps constructed on the Serrin principle. The dimensions of the room lighted up are 60 meters (196·8 ft.) by 30 meters (98·4 ft.). Each lamp throws off a light equal to about a hundred Carcel lamps, and these are surrounded respectively by a glass globe which serves to blend the light intensity. The cost of the four lamps, excluding the maintenance of the motive power, averages about ten pence per hour.

During the three months which this electrical light has been working, no inconvenience has been experienced, the light given off being beautiful and steady, and uncomparable to any other mode of illumination. The magneto-electrical machines have each cost 1500 frcs., or sixty pounds sterling, the whole arrangement amounting to 8000 frcs., or £320.

Table of comparative cost of electric light with other means of illumination.	Quantity of material required for producing light = 1 stearine candle.	Cost of a light intensity = to that of 700 stearine candles per hour.
Electrical light obtained by a magneto-electrical apparatus,	. . .	1*s.* 2*d.*
Ditto galvanic pile,	. . .	2*s.* 6*d.* 4*s.* 2*d.*
Coal Gas,	0·53 cubic feet.	2*s.* 8*d.*
Oil, (vegetable)	79·92 grains.	5*s.* 1*d.*
Tallow candle,	162·02 "	10*s.* 6*d.*
Stearine,	160·47 "	21*s.* 10*d.*
Wax,	127·45 "	27*s.*

In the preceding table, the following prices have been assumed: gas per cubic meter = 3*d.*; tallow, 17*d.* per kilogram; stearine candles, 3*s.* per kilogram; wax candles, 4*s.* 2*d.* per kilogram.

*From the *Electrical News*, Nov. 1, 1875.

To distribute the effect of the electric light in various directions and points in a uniform manner, the attempt has been made to pass the current through the different apparatuses by means of current deflectors, which break the currents passing through the lamps during so short a period, as to make the light appear to all intents and purposes as being continuous. The fact has been hereby utilized, that the impression made by light upon our visual organ remains intact during at least one-tenth of a second's duration. Moreover, the luminar arc between the carbon points becomes momentarily reproduced, provided the current interruptions are of only minute duration, a fact which has been repeatedly proved by the illuminating apparatuses of Siemens and Halske, as of late improved by Hafener Alteneck. Leroux has himself determined by experiments that the luminous arc between the carbon points becomes instantaneously reproduced, provided the interruption of the current does not exceed one-twentieth of a second. This last-mentioned authority also succeeded in dividing the electrical light by employing a rapid turning deflector, by means of which he alternately conducted the current of Bunsen's battery to two lamps, in such a manner that each of these received an equal amount of currents in equal times; the luminosity given out by these was also equal in both lamps.

On the other hand, it would appear that this *modus operandi* is neither cheap nor practical, and it has therefore been further attempted to divide the electric light without having recourse to the luminous arc. The results, however, have not been satisfactory, inasmuch as the cost of such illuminations rank almost equal to those of gas or petroleum lighting. These futile attempts induced Gramme to construct smaller machines with an equivalent light intensity of fifty Carcel lamps. These small lamps work very well alone; the light emitted is not perfectly steady; the best of the machines yet introduced, present a light of at least one hundred Carcel lamps, with an average cost price of £60.

Although the foregone description does not solve the problem concerning the devisability of the electric light, it is possible that the modern improvements made in this direction, coupled with the reduced cost, may at no distant period lead to the lighting up of our mills, railway stations, etc., by means of electricity.

THE WEAR AND REPAIRS OF PUMPING ENGINES.

A communication from Mr. H. R. Worthington, the inventor and constructor of the most successful direct acting pumping engine in the United States, complains with some reason of the statements made by Mr. E. D. Leavitt at the annual meeting of the American Society of Civil Engineers, in June, 1875, and was re-published from the transactions of the society in the JOURNAL, Vol. C, page 305, (Nov. 1875).

Mr. Leavitt's remarks as quoted in the JOURNAL were:

"The superiority of beam engines in respect to low cost for repairs is very clearly shown by the returns from Chicago, Louisville and Cleveland—this item, in many cases, ranks second to fuel only—and it is worthy of remark that at Chicago, with a duty of only 44,750,000 feet pounds; and coal at $8.56 per ton, water was delivered for 9·671 cents—while at Salem, with a duty of 59,000,000 feet pounds, and coal at $7.14 per ton, it costs 12.156 cents—per million gallons raised one foot high."

Mr. Worthington takes issue as to the facts set forth in these statements, and offers the following to substantiate his grounds.

Supposing an American duty of 44,750,000 at Chicago, and coal at $8.56 per ton of 2000 lbs. The cost of coal, per million of gallons raised one foot high, becomes 7·97 cents. While with the ratios of duty and price of coal at Salem given above, the cost of coal per million of gallons raised one foot high at that place becomes 5 cents. This leaves the cost of 1·701 cents at Chicago, and 7·156 cents at Salem, per million of gallons raised one foot high, to represent what Mr. Leavitt considers repairs of engine. The figures which form the basis of this estimate are questionable, and would doubtless change materially if scrutiny is made of them, and care be taken to remove the extraneous items of boiler repairs, etc., etc., and to equalize the proportion of cost of attendance, which becomes less per million as the number of millions increase. We will only refer to some data sent us by Mr. Worthington to show what discrepancy of statement exists. In making up the items which form the groundwork for for 12·156 cents, it appears that the cost of engineer, firemen and laborers was $2420.00, while the cost of coal was $3839.12; following this proportion the cost of attendance becomes 3·15 cents per million gallons. Now the relative cost of attendance at St. Louis could not

vary much from that at Salem, and if anything like 3·15 cents was incurred, the *profit* resulting from repairs of the St. Louis engine was something surprising. In the absence of reliable data, we need not follow this line of argument; in fact, there is but little connection between the final cost of water per million of gallons, and the repair-cost of an engine, which may be properly chargeable to the year when the repairs were made, and no comparison should be based upon it.

Repairs to an engine are the consequence of definite conditions, and proceed from wear or failure of parts; the comparison to be instituted, therefore, is what special liability does a type of engine present to be wasteful, in regard to wear or liability to accidental injury. Wear represents inordinate friction—improper facilities for lubrication—unsuitable arrangement of parts to avoid deposits upon the wearing surfaces, unnecessary carriage of moving weights. Does a beam engine, *per se*, possess any advantage in these regards over a direct acting engine, *per se?* Great expense, or in fact, any material expense for restoring the beam-centre pins or blocks; or for a fly-wheel engine; the main shaft or its blocks, or its crank pins; the repairs of a parallel motion, or any of the wrist pins; are tokens of improper construction, and are not to be assumed as defects of the kind. If an engineer or builder uses a slide for his cross-head, in lieu of a parallel motion, he measures the economy of construction against the economy of coal—if he so disproportions the surface of his slides that they wear out rapidly, he also measures the economy of construction against the economy of repairs; but the value of the type of engine is not affected by these considerations.

There are classes of engines where the type fails; there is a limit of economical possibility of expansion in a single cylinder engine, no matter how cunning the admission of steam, or how great the mass whose momentum absorbs the shocks, or distributes the inequalities of pressure, and this limit is quickly attained in water works' engines where the mass is omitted. And a similar limit is reached in a double cylinder rotation engine, when the attempt is made to run it for high duty with inadequate momentum.

Shocks, wear and breakage will ensue when this limit is passed.

There can be no question whatever but that horizontal or inclined cylinders must have an argument of comparative economy of original construction, with cost of restoring the pistons or cylinders at stated intervals; but this question does not apply to the broad one of

whether the direct acting or the beam engine is to be the type of the future. Even the *cost* of preserving cylinders of different engines is not to be accepted as a standard for their proper duration ; if the iron of a cylinder is improperly soft, if the packings are improperly set out, if they are not set out at all, if bad oil is used, if neglect is permitted, and many other contingencies, will make the best arranged cylinder the least durable. In brief, the limit of performance of the expansive steam engine with mass, with boilers of the highest evaporative quality, is about 130 millions per 100 lbs. burned, while that of engines without mass is about 80 millions per 100 lbs. burned. A yearly average performance will scarcely be two-thirds these values. The cost of attendance will be *about* proportionate to the duty, but we think the higher grade of engine will cost somewhat the most, relatively ; unfortunately the prime cost is against the higher engine, and the interest of investment can be computed against cost of attendance, coal or boilers. The writer has upon a previous occasion questioned the fairness of using the final statements of cost of water pumped per million gallons, by different cities, regardless of cost or nature of fuel, of expenses for repairs or ornament, of cost of attendance or salaries ; as applicable to the profit and loss of special engines, and the result of this particular example is a vindication of his views. B.

Original Publication of the Discovery that Flame Proceeds from Ignition of a Gas.—A curious question of priority has lately been discussed by the French Academy. It was to determine who is the first author that cited the experiment of the two candles as proving that flame is a phenomenon produced by ignition of gas. M. Melsens, in a recent historic disquisition on Van Helmont, attributed the first mention of the experiment to him. M. Chevreul said it had previously been described by Artephines, an Arabian alchemist of the second century. M. Calliburcés, having gone into the subject, first vindicated the priority for Galen, but later, found that Aristotle had spoken of the experiment five centuries earlier. In his "Meteorologica," Aristotle, to explain some luminous meteorological phenomena, compares them to the conflagration of gas which emanates from the wick of a candle recently extinguished. He was thus led to give an exact definition of flame ; one which does not differ essentially from those of Newton and Davy.

AMERICAN FOG-SIGNALS.

It is gratifying to our national pride to know that in all relating to that most important aid to navigation—the method or methods of giving notice to the bewildered mariner blinded by dense fogs, of the presence of dangerous rocks or shoals along a coast, or of the direction of safe channels and harbors—the United States Government has been very decidedly in advance of all other maritime powers.

Major G. H. Elliott, commissioned by the U. S. Lighthouse Board, under the sanction of the honorable Secretary of the Treasury, to make a tour of inspection of European Lighthouse establishments in 1873, in his valuable report, published by the Senate in 1874, remarks, after alluding to the question of the best illuminants for lighthouses: "I will only add that while the British and French systems are necessarily very much like our own, I saw many details of construction and administration which we can adopt to advantage, while there are many in which we excel. Our shore fog-signals, particularly, are vastly superior both in number and power." (*Report*, p. 12).

In the appendix to the U. S. Lighthouse Report for 1874, the chairman of the board, Prof. Henry, has given an interesting account "of the operations of the Lighthouse Board relative to fog-signals." Fog, the great danger and dread of the mariner, cannot be penetrated by the most brilliant of lights; and hence lighthouses, whatever their appointments, are quite valueless in this dire emergency. "The only means at present known for obviating the difficulty is that of employing powerful sounding instruments which may be heard at a sufficient distance through the fog to give timely warning of impending danger." (*Rep.* p. 83.)

"At the beginning of the operations of the lighthouse board, such instruments were employed for producing sound as had been used in other countries; these consisted of gongs, bells, guns, horns, etc. The bells were actuated by clock machinery, which was wound up from time to time, and struck at intervals of regular sequence, by which their position might be identified," (p. 85).

"Guns have been employed on the United States coast, first under the direction of General Bates, engineer of the twelfth district, at Point Bonita, San Francisco Bay, California. The gun at this station consisted of a 24-pounder, furnished by the War Depart-

ment. . . . Notice to mariners was given that after the 8th of August, 1856, a signal gun would be fired every hour and half hour, night and day, during foggy or thick weather. The first year 1,390 rounds were fired. These consumed 5,560 pounds of powder, at a cost of $1,487." (p. 85.) "This signal has been abandoned because of the danger attending its use, the length of the intervals between the successive explosions, and the brief duration of the sound, which renders it difficult to determine with accuracy its direction," (p. 86).

"Experiments in 1855. The lighthouse board was not content with the employment alone of the fog-signals in ordinary use, but directed a series of experiments in order to improve this branch of its service. For this purpose, the board employed Prof. J. H. Alexander, of Baltimore, who made a report on the subject, which was published among the documents. The investigations of Prof. Alexander related especially to the use of the locomotive steam-whistle as a fog-signal, and in his report he details the results of a series of experiments in regard to the nature and adjustment of the whistle, the quantity of steam necessary to actuate it, with suggestions as to its general economy and management," (p. 86).

"Mr. Daboll, of New London, Conn., had for several years been experimenting on his own account with reference to a fog-signal. His plan consisted in employing a reed trumpet, constructed after the manner of a clarionet, and sounded by means of air condensed in a reservoir, the condensation being produced by horse-power operating through suitable machinery. . . Mr. Daboll after this presented to the board a modification of his invention, in which a hot air engine of Ericsson's patent was substituted as the motive power instead of the horse," (p. 87). Mr. Daboll obtained a patent for his fog-trumpet, June 26th, 1860.

With reference to the various schemes proposed by inventors and patentees for sounding bells, whistles and horns, either by hand-power, or automatically, by the action of waves or of rolling vessels, Prof. Henry remarks, "the experiments which were made at this time, as well as all that have been made subsequently, conclusively prove that the penetrating power of the sound for practical use as a fog-signal depends upon the intensity of the motive energy employed. No instrument operated through levers and pumps by hand power, is sufficient for the purpose," (p. 89).

"The penetrating power of the whistle was compared with a Daboll trumpet, actuated by an Ericsson engine of about the same power. . . . The result was that the penetrating power of the trumpet was nearly double that of the whistle," (p. 90).

In October, 1867, a series of careful experiments was instituted at Sandy Hook, a bold headland projecting northward from the north-eastern coast of New Jersey, toward the harbor of New York city. "The principal object of these investigations was to compare different instruments, and to ascertain the improvements which had been made in them since the date of the last investigations, especially the examination of a new fog-signal called the siren, and the comparison of it with the Daboll trumpet," (p. 93). In this instrument, instead of a vibrating steel tongue or reed, a disk-valve in rapid rotation gives the periodic intermission or vibration to the air, or steam blast, requisite to produce a continuous or musical sound. "Under the direction of the lighthouse board, Mr. Brown, of New York, had made a series of experiments on this instrument in reference to its adoption as a fog-signal, and these experiments have been eminently successful," (p. 94). Mr. F. Brown obtained a patent for this instrument July 23d, 1867. The three instruments employed for comparison were:

1st. A Daboll trumpet of the largest size, being 17 feet long, 38 inches wide at its mouth, and carrying in its smaller end a vibrating steel tongue, or "reed" 10 inches long, and $2\frac{3}{4}$ inches wide, tapering in thickness from 1 inch at its fixed end, to half an inch at its free end. This instrument was arranged to give under a pressure of 15 to 30 pounds per square inch, a blast of five seconds duration, once a minute.

2d. A siren of about the same size, having its rotating disk valve arranged to give about 400 impulses or vibrations of air per second, and operated by a steam pressure varying from 50 pounds to 100 pounds to the square inch.

3d. A steam whistle having its cup 8 inches in diameter, and operated by the same pressures. A steam whistle previously used had its cup 12 inches in diameter and 20 inches long.

The siren was found to exceed the steam whistle in distance of penetration, in the ratio of 2 to 1, and the trumpet in the ratio of 58 to 50; but using a considerably higher pressure. Varying the pressure of steam on the siren, however, from 20 pounds to 100

pounds per square inch, increased the range of the instrument only from 51 to 61. That is to say, five times the pressure gave only about one-fifth additional penetrating power. "At the conclusion of the experiments at Sandy Hook, the siren was adopted as a fog-signal, in addition to the reed-trumpet and the locomotive whistle, to be applied to the most important stations, while large bells were retained for points at which fog signals were required to be heard at but comparatively small distances," (p. 99).

General Duane, the engineer in charge of the first and second lighthouse districts (embracing the coast of New England) under the direction of the lighthouse board made comparative experiments with these three signals, in 1871, and found that a first-class Daboll trumpet, a 12 inch steam whistle, and a first-class siren had the relative powers of 4, 7, and 9. The trumpet was audible at a distance of 12 miles, the whistle about 20 miles, and the siren farther, but how much was not ascertained. The relative expenditure for fuel was: for the trumpet 1, for the whistle 3, for the siren 9, (p. 101). From which General Duane concludes, "It will thus be seen that the siren is the most expensive of the fog-signals as regards maintenance, and that it is adapted only to such stations as are abundantly supplied with water and situated in the vicinity of machine shops where the necessary repairs can be promptly made. On the other hand as it is the most powerful signal, there are certain stations where it should have the preference. . . . The steam whistle is the simplest in construction, most easily managed, and kept in repair, and requires the least attention of all the fog-signals. It is sufficiently powerful for most localities, while its consumption of fuel and water is moderate. . . . The Daboll trumpet operated by a caloric engine, should only be employed in exceptional cases, such as at stations where no water can be procured," (p. 102). The difficulty of obtaining fresh water is at many stations very great.

Prof. Henry expresses a preference for the most powerful sounding apparatus for a fog-signal, and says: "In the foregoing remark we think the General has expressed a somewhat undue partiality for the whistle, and somewhat over-estimated the defects of the other instruments. The trumpets with Ericsson engine have not been abandoned. . . . They are preferred by General Woodruff, who finds no difficulty in keeping them in repair," (p. 102.)

Turning now to recent English investigations on fog-signals, instituted by the Trinity House, of London, during the year 1873, and

principally conducted by Prof. Tyndall, we find a remarkably concordant testimony as to the value of these instruments. Prof. Tyndall in his report to the Trinity House remarks: "To the late Mr. Daboll, of the United States, belongs the credit of bringing large trumpets into use as fog-signals. At Dungeness one of his horns had been erected under his own superintendence; and wishing to make myself acquainted with its performance, we steamed thither to-day. (Oct. 15, 1873.) On examining the horn, I was struck by its similarity in all essential particulars to the horns employed at the South Foreland. Considerable improvements in the working of the horn have been introduced by Mr. Holmes, but the horn itself is substantially that of Daboll," (cited in Maj. Elliott's *Report*, p. 40). The English patent of Mr. F. H. Holmes for this fog-signal, is eleven years later than the American patent of Mr. C. L. Daboll, being dated March 14, 1871; and the only essential difference or "improvement" therein indicated is an intermittent horizontal rotation mechanically given to the Daboll trumpet.

Prof. Tyndall also remarks: "On the 8th of October another instrument which has played a specially important part in these observations, was introduced. This was a steam siren, constructed and patented by Mr. Brown of New York, and introduced by Prof. Henry into the lighthouse system of the United States. As an example of international courtesy worthy of imitation, I refer with pleasure to the fact, that when informed by Major Elliott, of the United States army, that our experiments had begun, the lighthouse board at Washington, of their own spontaneous kindness, forwarded to us for trial a very noble instrument of this description, which was immediately mounted at the South Foreland."—(*Pop. Science Monthly*, March, 1875, vol. vi, p. 543.)

Prof. Tyndall made the curious observation, frequently repeated, that in certain peculiar states of the atmosphere an inferior sounding instrument can be heard at a greater distance than a superior one. Details of these remarkable results are given in his treatise on "Sound," 3d edition. On October 17th, "at 11·30 A.M. the mastery of the siren over the gun was pronounced; at 12·30 the gun slightly surpassed the siren; at 1, 2 and 2·30 P.M. the gun also asserted its mastery." On October 21st, "at 11 A.M., distance $6\frac{1}{2}$ miles, when the siren made itself heard through the noises of wind, sea, and paddles, the gun was fired, but though listened for with all

attention, no sound was heard. . . On the 27th also the siren was triumphant; and on three several occasions on the 29th its mastery over the gun was very decided. Such experiments yield new conceptions as to the scattering of sound in the atmosphere."—(*Sound*, p. 314.)

Prof. Tyndall concludes: "An absolutely uniform superiority on all days cannot be conceded to any one of the instruments subjected to examination; still our observations have been so numerous and long continued as to enable us to come to the sure conclusion that on the whole the steam siren is beyond question the most powerful fog-signal which has hitherto been tried in England. It is specially powerful when local noises, such as those of wind, rigging, breaking waves, shore surf, and the rattle of pebbles, have to be overcome. Its density, quality, pitch and penetration render it dominant over such noises after all other signal sounds have succumbed. I have not, therefore, hesitated to recommend the introduction of the siren as a coast signal," (*Sound*, p. 316). And in a communication to the Royal Institution, Jan. 16, 1874, Prof. Tyndall says: "Of all the instruments hitherto examined by us, the siren comes nearest to the fulfillment of this condition; [an energy sufficient to survive a large amount of dissipation;] and its establishment upon our coasts will in my opinion prove an incalculable boon to the mariner."—(*Proceedings Roy. Inst.*, vol. 7, p. 178.)

Sir Frederick Arrow, the deputy master of the Trinity House, and executive officer of the lighthouse service of England, bears the similar testimony, that the instruments employed "have varied in a remarkable manner at different times, but for general efficiency there is no doubt that the American siren takes the first place," (Elliott's *Rep.*, p. 62). Sir Frederick Arrow had previously (in the summer of 1872), visited our country with the special view of examining into our system of fog-signalling, and had accompanied Professor Henry in some of his experimental observations in the harbor of Portland on the coast of Maine.

The three most powerful and trustworthy fog-signals now known —the steam whistle, the fog trumpet and the siren, are thus seen to be of American invention and introduction; and it would be unjust to close this notice without the distinct recognition and record that to the careful and laborious investigations and experiments of the

distinguished chairman of the lighthouse board, Professor Henry, prolonged through a series of years and prosecuted under a great variety of conditions, is largely to be attributed the acknowledged superiority of our fog-signal service.

Professor Tyndall in his article "On the Motions of Sound," published in the *Pop. Science Monthly* for August, 1875, (p. 420), after very briefly alluding to a few of Prof. Henry's researches on the characteristics of sounding instruments, as applicable to the purposes of the lighthouse board, pays him this fitting tribute: "Add to this the fact that their eminent chairman gives his services gratuitously, conducting without fee or reward experiments and observations of the character here revealed, and I think it will be conceded that he not only deserves well of his own country, but also sets his younger scientific contemporaries, both in his country and ours, an example of high minded devotion." T.

HIGH CHIMNEYS.

From *The Builder*, London, Nov. 20th, 1875, we extract the following description and dimensions of two chimneys:—

The first, at the Crawford Street Chemical Works, Port Dundos, Glasgow, has a total height from foundation to top of coping of 468 ft., and from ground line to summit, 454 ft., the outside diameter at foundation being 50 ft., and at ground surface 32 ft., and at top of coping, 12 ft. 8 in. The number of bricks is as follows:—

Common Bricks in shaft, ...	1,142,532
Composition and fire bricks for inside cone, . . .	157,468
Common bricks for flues, ...	100,000
Total number of bricks . .	1,400,000

Weight of bricks about 5000 tons.

The second, at the Kay Street Machine Works, Bolton, Lancashire, has a total height from ground level of 367 ft. 6 in. Octagonal on plan, 14 ft. on every side, or 112 ft. in girth at bottom; 5 ft. 6 in. on every side, or 44 ft. girth, at top. Thickness of brickwork at bottom, 8 ft.; thickness of brickwork at top, 1ft. 6 in. 800,000 bricks and 120 tons of stonework were used.

The top, with cornice and mouldings, required 30 tons of stone and cement.

Chemistry, Physics, Technology, etc.

THE DIATHERMACY OF MOIST AIR.

By J. L. Hoorweg.

Translated from Poggendorf's Annalen, by C. B. Dudley, Ph.D.

In the year 1861, Tyndall communicated to the Royal Society, of London, a series of experiments upon the absorption of radiant heat by gases, which, in the following year was extended by experiments upon vapors. Tyndall employed the following apparatus: A very sensitive thermo-pile was fitted with two reflectors. On both sides of the thermo-pile, at appropriate distances, two sources of heat were placed. Between the thermo-pile and one source of heat was a horizontal brass tube, some three feet long, closed at both ends by rock salt plates, and connected through side openings with drying apparatus and air pump. When the experimental tube was exhausted, both sources of heat produced an equal effect on the thermo-pile; if, therefore, the entering gases or vapors produced a perceptible absorption, this could readily be perceived by the deviation of the galvanometer needle.

At the same time with Tyndall, and at first without knowing of his experiments, Magnus was occupied with the same subject. In his case, a thermo-pile was fastened to the plate of an air pump. Over the pile was placed a glass vessel, open at the bottom, and which fitted air-tight to the pump plate. This vessel had two openings, one perpendicularly over the pile, and the other to the side of it. Through the last, passed a brass rod, which carried a screen; through the first, a tube, to which a larger glass vessel was cemented air-tight, and which carried above a second glass vessel containing boiling water. The gases whose absorption was to be observed, were let into the larger glass vessel by a stop-cock.

The results of these two fine series of investigations may be said to agree very well in general. It is with difficulty, however, that this is seen in the following table :

Name.	Absorption of gases according to Tyndall.	Diathermacy of gases according to Magnus
Air, ...	1	100·
Oxygen, ...	1	100·
Hydrogen, . . .	1	96·5
Carbonic Oxide, . .	90	88·8
Carbonic Acid, . .	90	90·3
Nitrous Oxide, . .	355	83·3
Marsh Gas, . . .	403	81·2
Olefiant Gas, . . .	970	52·1
Ammonia, . . .	1197	43·7

Tyndall employed a tube 2 feet 8 inches long, Magnus one of 10 inches. By the following considerations, the agreement may, perhaps, be more clearly seen. According to Tyndall's "Heat as a Mode of Motion," German authorized edition, page 455 (Appleton's Edition, page 333), air saturated with moisture absorbs 90 times stronger than dry air, and in so doing, takes up 10 per cent. of the total heat. The absorption of dry air is, therefore, $\frac{1}{9}$ per cent. in a tube 2 feet 8 inches long, or in a tube 10 inches long, about $\frac{1}{27}$ per cent. or 0·037 per cent. ; consequently :

NAME.	Absorption in per cent. according to Tyndall.	Diathermacy in per cent. according to Tyndall.	Deviation which should be obtained by Magnus according to Tyndall.	Deviation according to Magnus.	Difference.
Vacuum, ...	0·	100·	14·403	16·4	+2·
Air, ...	0·037	99·96	14·4	14·4	0·
Oxygen, ...	0·037	99·96	14·4	14·4	0·
Hyrogen, ...	0·037	99·96	14·4	13·9	—0·5
Carbonic Oxide, . .	3·33	96·67	13·93	12·8	—1·13
Carbonic Acid, . .	3·33	96·67	13·93	13·0	—0·93
Nitrous Oxide, . .	13·13	86·87	12·51	12·0	—0·51
Marsh Gas, . . .	14·91	85·09	12·25	11·7	—0·55
Olefiant Gas, . .	35·89	64·11	9·24	7·5	—1·74
Ammonia, : . . .	44·22	55·78	8·03	6·3	—1·73
Moist Air, . . .	3·33	96 67	13·93	14·4	+0·5

As may be seen, the deviation in the case of vacuum and saturated air, is, according to Tyndall, too great; whence it follows, that air with which Magnus compared all other gases, had, according to Tyndall, a much weaker absorption than was found by Magnus; while moist air, according to Tyndall again, absorbs much more than Magnus states. According to Tyndall's statement, there is almost no difference between air and vacuum; according to Magnus, on the other hand, there is none between dry and moist air.

Of these two results, that which concerns the absorption of moist air is of very great interest to meteorologists. While, therefore, the absorption of dry air did not come into further consideration, an interesting contest arose between the two experimenters upon the behavior of water vapor towards radiant heat.

After Magnus had pointed out the hygroscopic character of rock salt, Tyndall showed that when one reflector was placed within the experimental tube, the results remained the same; and when Magnus called Tyndall's attention to the impurity of London air, Tyndall immediately concluded to repeat the experiments in the pure atmosphere of the Isle of Wight. Still, again, moist air showed considerable absorption.

Later, in December, 1862, Tyndall read before the Royal Society a paper upon the absorption of moist air, in which were described experiments with *open* tubes, which confirmed his previous statements. The tube was filled alternately with dry and saturated air, and in every case the dry air showed itself by smaller, and the moist air by a greater absorption. Moreover, at the end of this paper, an experiment was mentioned, in which not only the rock salt plates, but also the tube itself were dispensed with. Between one source of heat, C,

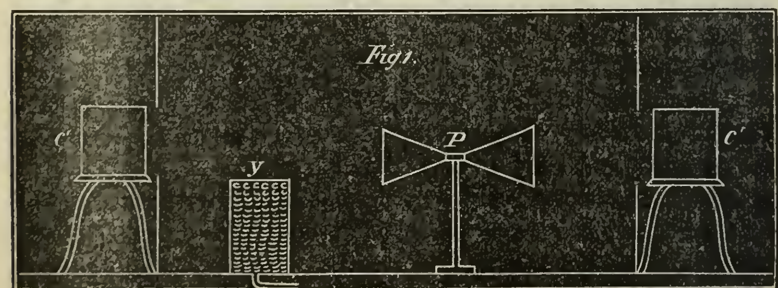


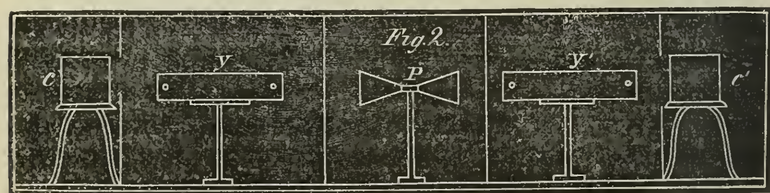
Fig. 1, and the thermo-pile, P, was placed a cylinder, Y, $3\frac{1}{2}$ inches in diameter, which was filled alternately with calcium chloride, or with

fragments of rock crystal, which had been moistened with distilled water. Air was then forced through the cylinder between the cube and the thermo-pile. A part of the air of the laboratory, was, therefore, replaced, now by dry, and now by saturated air, and in every case Tyndall observed a deviation which confirmed his view. And not Tyndall alone, but also Prof. Wild, at Zurich, conducted experiments with open tubes; and in his case, a still greater absorption was observed than Tyndall gave. Moreover, Tyndall had the pleasure of showing to Magnus himself, his experiment with open tubes, and it is, therefore, entirely explicable that Tyndall should trust that "*the matter had been placed entirely out of the range of pure reflection.*"

2. But when we look more closely over the part which Magnus has had in this matter, our view is somewhat changed. In the first place, Magnus defends his apparatus against Tyndall's doubts in regard to it. He claims that his apparatus would not have been able to give results agreeing so closely with Tyndall's, if it had such grave faults as Tyndall affirms. On the contrary, he says, because in my case the gas is directly between the source of heat and the thermo-pile, without an intervening wall, Tyndall's experiments are the less to be relied upon.

In opposition to this, Tyndall says, that the direct contact of the source of heat and the gas must induce currents which would influence the result; and that in his own experiments the presence of the thermo-pile in the experimental tube caused a disturbance. The first objection is emphasized by Wild, who says that he was able to obtain no results, whatever, according to Magnus' method. Magnus answers Wild by saying that the latter employed a metallic tube, and consequently a good conductor, instead of a glass one, which he himself used. Still further he says, in the case of his own experiments, the disturbing currents were not there, for when he placed a rock salt plate so as to divide his tube into two equal parts, and then, after exhausting the upper part, experimented only with the lower half of the tube, everything was just as before. As to the disturbance which arose when the thermo-pile was placed inside the tube, Tyndall maintains this on the ground of experiments, in which only half of the pile was in the tube, and the other half was in contact with the outside air, which, however, is quite another thing than when the whole pile is placed within the experimental tube.

After Magnus, during his stay in London, had seen Tyndall's experiments, those with open tubes appeared to him to deserve the greatest confidence, and he concluded to repeat them on his return home. But, to his great astonishment, he always obtained opposite results. The blowing of moist air always manifested itself by a warming of the pile. The cause of this did not long remain unknown. The air blown through the open tube reached the pile itself, the water vapor was condensed, and heat was set free. Magnus, therefore, naturally supposed that Tyndall had made a mistake in the direction of the deviation; but not long after, Wild published his splendid investigations, which unequivocally confirmed the correctness of Tyndall's views. Magnus was at a loss to account for his error, and concluded, therefore, to repeat Wild's experiments with entirely similar apparatus. In so doing, he found that in his earlier experiments, the thermo-pile had stood too close to the experimental tube, for now the air failed to reach the pile, and he obtained the same deviation as Tyndall and Wild.



Wild arranged his apparatus as follows: On both sides of the pile, P, Fig. 2, were placed brass tubes Y and Y,′ 60 centimeters long, which again were flanked by the Leslie's cubes, C and C,′ which served as sources of heat. When now the air of one tube was replaced by moister, and that of the other by dryer air, there resulted in every case a consid erable deviation of the needle. On repeating this experiment, however, Magnus soon observed that even when moist air was blown through both tubes, a deviation of the needle resulted, which was increased when one tube was blackened and the other polished. Still farther, when both tubes were lined with velvet, and the air blown through, the direction of the deviation was changed, the moister air showing the greater warming of the pile.

After reflecting on the cause of these phenomena, Magnus showed in the plainest manner possible, that water is always percipitated on the inner wall of the tube even from air not saturated. This *vapor*

hesion, as Magnus calls it, takes place when the temperature of the tube is about 12° C. higher than that of the air.

The explanation of the whole matter, therefore, is as follows: The heat reaches the pile not by direct radiation, but by repeated reflections from the inner wall of the tube. In the case of an open tube, this inner wall is always covered with more or less water from the air of the laboratory, which through absorption diminishes reflection. If now moister air is blown into one tube, still more water is deposited, and the reflection is still more diminished, while the blowing of dry air into the other tube evaporates in great measure the water layer, and consequently the reflection is increased. The observed deviation of the needle arises, therefore, not from the absorption of water vapor, but from the absorption of water itself.

This explanation of Tyndall's observations is so natural and satisfactory that no one is astonished to see Magnus at the conclusion of his paper express the conviction that if Tyndall and Wild would repeat his experiments they would no longer maintain the great absorption of water vapor.*

Let us not forget still further that Magnus did not pass by Tyndall's experiment in the open air, Fig. 1. He repeated this in the following manner: Four glass tubes about 66 centimeters long and closed at one end were placed horizontally side by side between the thermo-pile and the cube. Each of these tubes had 40 small holes through its upper side and the open ends were joined to a cross tube, which was connected with a bellows. When the bellows were in action, therefore, a number of fine currents of air were obtained which arose freely between the source of heat and the pile. When now air, saturated with water vapor and air quite dry, were alternately forced through the system of tubes, no change in the heating of the pile was to be observed, while on the other hand, carbonic acid, which according to Tyndall, absorbs just as much radiation as water vapor, occasioned in every case a noticeable cooling.

It is evident now, I think, in view of Magnus' experiments upon vaporhesion, that experiments with tubes, be they open or closed,

* And yet Tyndall (Radiant Heat, Appleton's Edition, p. 394) has shown by using a large experimental tube, and sending through it by means of a rock salt lens, a converging beam of heat, which consequently was not at all reflected from the inner wall of the tube, that the same results substantially were obtained as when a smaller tube was used, and most of the heat which reached the pile was reflected from its sides.—Trans.

deserve no confidence, and that Tyndall's single experiment in the open air is outweighed by Magnus' experiment of the same kind with negative result. I do not hesitate, therefore, to affirm that there is to-day no firm ground for accepting the absorption of water vapor as an incontrovertible fact.

3. It has been my wish for some time to arrive at greater certainty in reference to this important question, but only at the present moment have I found a favorable opportunity. I therefore concluded to begin the experiments at once. It was clear to me from what had previously been done in this field, that I could only employ experiments in the open air, and those too without the protecting covering with which Tyndall surrounded his apparatus.* I suspected that in the case of Tyndall's experiments, the current of dry or moist air, as the case may be, had been reflected and thrown against the reflector of the thermo-pile, in which event the same change of reflection must result as in the case of experiments with tubes. I concluded, therefore, to repeat Tyndall's experiment (Fig. 1) with a cylinder of the same size, Y, but without the covering, which might occasion currents within, as much as it kept them off from without.

To a very sensitive Wiedemann's reflecting galvanometer, which had already on several occasions† done me good service, and was rendered completely astatic by an auxiliary magnet. I connected a common Melloni thermo-pile, such as Ruhmkorff furnishes. The pile was fitted with two reflectors and on the right and left two Leslie's cubes were arranged in such a way that the needle showed no deviation. The telescope and scale were at a distance of 3650 millimeters. The arrangement was quite like Wild's (Fig. 2), but instead of the two tubes Y and Y′, there were two cylinders similar to the one which Tyndall used. One cylinder I filled with calcium chloride, and the other with bits of clean quartz which had been moistened with distilled water. When the air was forced through the cylinders, a current of dry air arose on the left, and of moist on the right, and the influence of these on the heat radiation could readily be observed This experiment was repeated many times, and although the two sources of heat, each by itself, occasioned a deviation of more than 500 scale divisions, I have never been able to observe the slightest

* Phil. Transactions, 1863.

† Maandblad van Natuurweten Schappen, Amsterdam, 1872 and 1873.

movement of the mirror when air was forced through the cylinders. And yet the thermo-pile was sensitive enough to show a distinct cooling when carbonic acid was forced through the calcium chloride cylinder. I also obtained quite a deviation when the second cylinder only was employed which was filled successively with bits of quartz which had been moistened with the following liquids: alcohol, methyl alcohol, sulphuric ether, acetic ether, bisulphide of carbon, and benzol.

The results of these experiments are arranged here in the same manner as Tyndall* gives them:

TABLE I.

Name.	Deviation.	Absorption.
Hydrogen,	unnoticeable.	0·
Carbonic Acid,	6·	1·2
Bisulphide Carbon,	8·	1·6
Illuminating Gas,	17·5	3·5
Benzol,	20·	4·
Methyl Alcohol,	36·	7·2
Alcohol,	45·	9·
Sulphuric Ether,	84·	16·8
Acetic Ether,	120·	24·
Total,	500·	100·

The series of vapors is exactly the same that Tyndall found. Moreover, the result was the same when the cylinder containing the liquids was placed on the right instead of the left of the pile. In general, personal equation and anomaly are entirely absent in these experiments, and anyone can easily repeat them with the same simple apparatus. The experiments were performed at different times in the day, and under different circumstances as to temperature. Finally I must add that in these experiments the very purest possible liquids were not employed, as was the case subsequently.

Although there were no disturbing influences at work, I could not perceive with the utmost straining of the attention, any absorptive action in moist air, and so I came to the same result as Magnus. Only two possibilities remained: either in Tyndall's experiments the protecting covering was the cause of the deviation, or my thermo-pile was not sensitive enough to show the action of water vapor.

In order to decide between these two possibilities, I undertook an

* *Philosophical Magazine*, 1864, vol. 28.

experiment with an ascending current of air of greater length. For this purpose I had prepared two metallic boxes, 25 centimeters long, 9 centimeters broad, and 5 centimeters high, closed on all sides, but fitted on one side with a tube and on the top with numerous small holes. These boxes replaced the tubes Y and Y′, (Fig. 2). The two cylinders remained respectively filled with calcium chloride and moistened quartz fragments, but were closed above with a perforated cork, through which passed a glass tube, which was connected with the side of the box by a bit of rubber tubing. The arrangement of the apparatus is shown in horizontal projection in Fig. 3, in which C and C′ are Leslie's cubes, P, the thermo-pile, Y and Y′ the two boxes, Q and Q′ the cylinders, and L the tube by which the cylinder was connected with a bellows. With this arrangement, as will be seen, it was possible to obtain from one box a current of dry air, and from the other a current of moist air, which, if water vapor caused any absorption, would destroy the heat equilibrium of the thermo-pile.

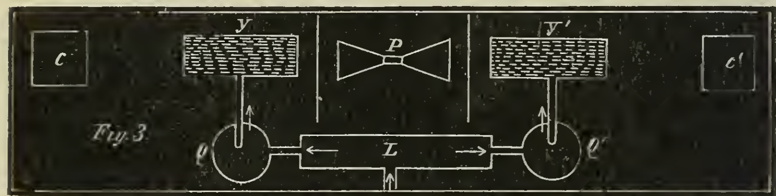


Fig. 3.

On performing this experiment, I could with the greatest care observe a slight deviation of the needle. There was therefore actually an absorption in water vapor, and for Tyndall's result, the superiority of his thermo-pile was to be thanked. I could estimate the absorption at not more than ½ per cent. But the deviation of the needle was insufficient for me to ascertain the matter with certainty, and so I placed the two boxes by the side of one another on the same side of the thermopile, and thus, as Tyndall did, obtained a colnmn of moist and dry air alternately. By this means the ascending air current became 50 centimeters long. There now seemed no chance for mistake. Every time that the moist air arose, a deviation of 1 millimeter resulted in favor of the compensating source of heat, and on the employment of dry air a deviation of 3 millimeters in favor of the other cube. The total deviation when one source of heat was shut off was 294 millimeters. There was, therefore, an absorption of

1·7 per cent. On the same evening I obtained with illuminating gas and alcohol vapor the following results:

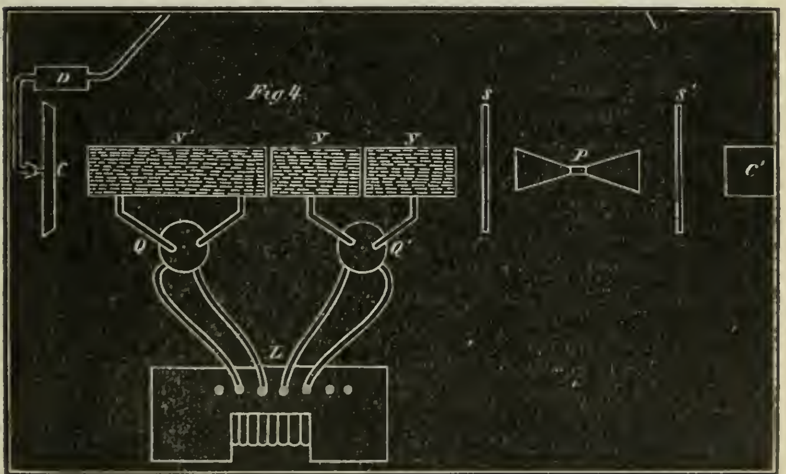
TABLE II.

Name.	Deviation.	Absorption.
Moist Air, ...	4·5	1·6
Illuminating Gas, . .	11·6	3·6
Alcohol, ...	49·	16·7
Total, ...	294·	100·

The temperature of the room was 9° centigrade. On a subsequent day at the same temperature I obtained the following results:

TABLE III.

Name.	Deviation.	Absorption.
Moist Air, ...	4·	1·7
Bisulphide Carbon, . .	5·	2·1
Alcohol, ...	40·8	17·
Sulphuric Ether, . .	43·5	18·
Methyl Alcohol, . .	43·	18·
Formic Ether, . . .	53·	22·1
Acetic Ether, . . .	63·5	26·5
Total, ...	240·	100·



For further investigations I increased the length of the ascending air current to one meter, employing for that purpose the apparatus whose horizontal projection is given in Fig. 4. Y, Y are the boxes

already described, each 25 centimeters long. Y′ is another box of the same kind, but 50 centimeters long, and with its top filled with small holes. Q and Q′ are the two well known cylinders which were now always filled with the same material, that is, either with calcium chloride or with moistened fragments of quartz. The cork of each was fitted with two tubes, which, by rubber tubing, were connected with Y and Y′. Two tubes were also fastened into the under part of the cylinders by which the whole arrangement was connected with the acoustical wind chest L, which now took the place of the common bellows. When, therefore, the corresponding keys of the wind chest were pressed down, a four-fold current of air issued into the boxes Y and Y′, expanded in them, and finally arose through the small holes in their upper surface, between the thermo-pile and the source of heat.

But now the boiling water did not furnish sufficient heat, and so in place of the Leslie's cube I employed a copper plate, C, covered with lampblack, and heated from behind by a Bunsen burner. To regulate the flow of gas, the apparatus D, which was invented by Cavaille-Col., and is attached by Konig to his syren, was placed in the gas connections. (See *Catalogue d'Instruments d'Acoustique.*) There seemed now not the slightest chance for doubt. Every time a current of dry air displaced the moist air of the laboratory there resulted a deviation in favor of the heated copper plate, as the following observation shows:

DRY AIR.

Scale Reading Without Blowing.	With Blowing.	Deviation.
27	32	5
28	35	7
29	35	6
30	35	5
31	36	5
30	35	5
29	35	6
From the copper plate alone, . . .		322

On employing air saturated with water vapor there resulted a deviation of 1 millimeter, always in favor of the compensating Leslie's cube. This was shown also in the plainest manner possible by the change in the direction of the needle.

On the whole I obtained on this evening the following results:

TABLE IV. TEMPERATURE 9° C.

Name.	Deviation.	Absorption.
Water vapor,	6·5	2·
Alcohol,	75·	23·3
Total,	332·	100·

On the following evening I obtained the following numbers:

TABLE V. TEMPERATURE 7·5° C.

Name.	Deviation.	Absorption.
Water vapor,	7·	2·
Bisulphide Carbon,	17·	5·
Sulphuric Ether,	67·	19·7
Alcohol,	71·	21·
Methyl Alcohol,	78·	23·
Formic Ether,	79·	23·2
Acetic Ether,	92·	27·
Total,	340·	100·

It is readily seen that the agreement is better, as might be supposed in such difficult experiments. I doubt not that it can be carried still closer, but my eye was chiefly directed to the behavior of water vapor.

From table V, it is clear that the greater length of the absorbing layer increases the absorption, although not in the same proportion, as was the case in Tyndall's experiments. I regard it, however, as certain that as far as concerns water vapor my experiments cannot be in error more than $\frac{1}{2}$ per cent.

I was curious to know whether the behavior of water vapor towards radiant heat was influenced in any great degree by the temperature of the room. For the purpose of deciding this I made a number of experiments in a room heated about 11° C. higher than before. The following are some of the results:

After blowing. Dry Air.	Starting point on Scale.	After blowing. Moist air.	Deviation.
21·	16·	9·	12·
22·	16·	9·5	12·5
21·5	16·	9·	12·5
21·5	16·	8·5	13·
From the copper plate alone,			535·

TABLE VI.

Name.	Deviation.	Absorption.
Water vapor, . . .	12·5	2·3
Sulphurous Acid, . .	124·	25·
Alcohol, ...	149·	28·
Total, . . .	535·	100·

In reality an increased absorption resulted, but not in the proportion that I expected.

Still there is no doubt about the correctness of these observations, for a week afterwards I obtained the following numbers at 18° C.:

TABLE VII.

Name.	Deviation.	Absorption.
Water vapor, . . .	9·5	2·2
Alcohol, ...	110·	36·
Total, . . .	420·	100·

At the same higher temperature I made experiments with the two Leslie's cubes and the two boxes Y, whose complete length was 50 centimeters, that is with the same apparatus, as in the case of Tables II and III, and obtained the following results :

TABLE VIII.

Name.	Deviation.	Absorption.
Water vapor, . . .	3·5	1·
Bisulphide of Carbon, .	5·	2·5
Alcohol, ...	38·	19·
Methyl Alcohol, . . .	56·	28·
Sulphuric Ether, . .	56·5	28·2
Acetic Ether, . . .	75·	37·6
Total, . . .	200·	100·

It appeared to me not unimportant to try likewise some experiments with another source of heat. For this purpose I employed again the apparatus represented in Fig. 4, in which the ascending air current was 1 meter long :

TABLE IX. TEMPERATURE 14° C.

With a common gas lamp, circular burner, and glass chimney.

Name.	Deviation.	Absorption.
Water vapor, . . .	2·	0·4
Alcohol, ...	46·5	9·7
Total, . . .	480·	100·

TABLE X. TEMPERATURE 14° C.

With a plate of unglazed brick, heated from behind by a Bunsen burner.

Name.	Deviation.	Absorption.
Water vapor,	7·	2·3
Alcohol,	78·	26·
Sulphuric Ether,	83·	27·5
Formic Ether,	86·	28·6
Acetic Ether,	98·	32·6
Methyl Alcohol,	111·	37·
Total,	300·	100·

TABLE XI. TEMPERATURE 14° C.

With a four tube Bunsen burner, blue light, scarcely visible.

Name.	Deviation.	Absorption.
Water vapor,	unnoticeable.	0·
Alcohol,	16·	6·
Total,	262·	100·

It is evident from the tables that with different sources of heat the series of vapors is not the same. Tyndall found the same thing to be true. The series is as follows:

TABLE XII.

Leslie's Cube.	Heated Copper Plates.	Heated Brick.
Water vapor,	Water vapor,	Water vapor.
Bisulphide of Carbon,	Bisulphide of Carbon,	Bisulph. Carbon.
Alcohol,	Sulphuric Ether,	Alcohol.
Methyl Alcohol,	Alcohol,	Sulphuric Ether.
Sulphuric Ether,	Methyl Alcohol,	Formic Ether.
Formic Ether,	Formic Ether,	Acetic Ether.
Acetic Ether,	Acetic Ether,	Methyl Alcohol.

Especially worthy of note is the behavior of the vapor of methyl alcohol, which in the case of the heated brick suddenly takes the highest rank in the series.

In order to present a better view of the subject, I give again here the results which I have obtained upon the absorption of water vapor together with those upon alcohol vapor.

TABLE XIII.

Influence of the length of the ascending air current.

Name.	Air Column of 9 cent.	60 cent.	100 cent.
Water vapor,	imperceptible.	1·6	2·
Alcohol,	9·	17·	21·

TABLE XIV.

Influence of the kind of radiation. Apparatus, Fig. 4. Temperature 14° C.

Name.	Leslie's cube.	Heated Cop. plate.	Heated brick.	Gas flame.	Bunsen burner.
Water vapor, .	3·*	2·2	2·3	0·4	imperceptible.
Alcohol, . .	27·	28·	26·	9·7	6·

When we look back over the tables given above, the strife between Tyndall and Magnus appears to have been a very natural one. Tyndall overrated the absorption of water vapor, on account of vapor-hesion; while Magnus infinitely underrated it on account of the shortness of his experimental tube. Magnus used in his experiments a tube 26 centimeters long. If we place the absorption in this at ½ per cent., this would give a deviation of only 0·08 of a scale division, in case the total deviation was 16·4 scale divisions. Magnus obtained only 0·1 of a scale division.

If we look at Table XIII, we see substantiated for vapors what has long been known in the case of solid and liquid bodies, that each following layer lets through more proportionally than the preceding one. Accordingly I believe that 100 meters of common air are far from being in condition to occasion the result which Tyndall expects from 10 feet, that is that 10 per cent. of the radiation which it receives is absorbed.

Still no one will call in question the value of Tyndall's splendid work, or of his speculations upon the great interest which attaches itself to the behavior of water vapor, of which he was the discoverer.

Utrecht, Feb., 1875.

Transformation of Lead to Galena.—Mr. Peter Spence, F. C. S., etc., exhibited at the Literary and Philosophical Society of Manchester, Nov. 2, 1875, a piece of 2 to 3-inch lead pipe in which the metal had been entirely transformed into galena, the crystallization being visible through the whole of the specimen. The pipe had been used for the conveyance of gas ammoniacal water, and was sunk under ground. A considerable leak of gas-water having occurred, a constant atmosphere of sulphide of ammonium would surround the pipe, and this seems to have been the cause of the conversion of the lead into sulphide, as only that part of the pipe which was in the vicinity of the leak was found to be transformed.

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* These two numbers were obtained by a removal of the scale to 7·5 meters instead of 3650 millimeters, as in the case of the former experiments.

PHENOMENA OF INDUCTION.

By Professor EDWIN J. HOUSTON.

The publicity given by notices in several newspapers within the past few weeks, of an alleged discovery of a new force by Mr. T. A. Edison, of Newark, N.J., which has been styled by him "Etheric Force," and the manifest general interest in these notices, lead me to present the following communication for the pages of the JOURNAL. In the JOURNAL OF THE FRANKLIN INSTITUTE for June, 1871, will be found a published description of some experiments which I made shortly prior to the date of publication, and which bear, both in method and results, a partial resemblance to those by Mr. Edison.

The experiments alluded to were made with a Ruhmkorff induction coil, capable of throwing the induced spark six inches in free air. I found that by connecting one of the poles of the secondary coil with a gas pipe by means of a good conducting wire, and the other pole by similar means, either with a large insulated conductor or with a semi-insulated conductor, as for example, by allowing the wire to rest on a dry lecture table, that the volume or quantity of the spark was greatly increased, and at the same time the characteristic whitening of the condensed spark produced. These results I attributed entirely to a condensation of the spark by connection with extended surfaces, similar to the condensation produced by the introduction of a Leyden battery into the circuit.

During the progress of the experiments the following facts were noted, which bear upon the observations of Mr. Edison. While the interrupter of the coil was in operation, making and breaking contact with the battery, sparks could be drawn from any metallic objects in the neighborhood of the coil, and, indeed, in adjoining rooms. For example, by holding a small metallic object in the hands, sparks were drawn, in an adjoining room, from a large pneumatic trough, in connection by soldered joints with the water-pipes of the building. Similar sparks were drawn from a half-horse power engine, also in metallic connection with the water-pipes, and from the steam boiler in the chemical laboratory on the floor below. A person standing on the floor could draw sparks from any of the gas pipes in the adjoining rooms by holding a knife blade to the pipes or burners. These

results I of course attributed to the action of the induced electricity from the coil, and published a note of them merely as a new experiment with the induction coil. On first hearing of the alleged discovery of the "Etheric Force" by Mr. Edison, I was led to think it probable that the phenomena observed by him were similar to those noticed by me in 1871, but from the brief descriptions published in the newspapers, was unwilling to make a public note of my belief. In the *N. Y. Tribune*, of December 9, however, Dr. Beard, of New York, has published a fuller account of the manner in which the experiments were conducted, and as far as I can gather they are of a similar nature to mine, and I feel warranted in believing that they can all find a satisfactory explanation by the presence of *induced electrical currents*, without the intervention of any new force whatever.

Immediately on reading the first published account of Mr. Edison's experiments, I repeated my original experiments in connection with my friend, Professor Elihu Thomson, of Philadelphia.

I append a brief description of our experiments. The induction coil already mentioned was worked by means of an electro-poin battery of ten cells coupled for an intensity of ten. The elements of each cell consist of a single plate of zinc placed between two plates of carbon. The available surface in each cell is about three by six inches. One pole of the battery was placed in metallic connection with a gas pipe and the other in similar connection with a large insulated conductor. On working the interrupting break-piece, a torrent of characteristic white sparks of condensed electricity passed between the platinum points of the coil. Under these circumstances, that is, while the discharges were occurring between the points, sparks could be drawn from all metallic objects in the same room with the coil, or in adjoining rooms. The sparks were especially noticeable when metallic objects were approached to the gas or water pipes of the building, or to metallic surfaces in connection therewith, as in the case of the pneumatic trough, steam engines, and boiler before mentioned. As already implied, actual contact between the gas or water pipes and one of the wires leading from the coil, was unnecessary, as distinct sparks were afforded by a stove in the same room, and from another in an adjoining room.

In order to test the suspected similarity between these sparks and those described by Mr. Edison, we submitted them to the tests pro-

posed by him. We made a number of experiments and obtained the following general results, viz.:

First. The gold leaves of a delicate electroscope did not diverge on being brought into contact with metallic objects yielding the sparks, although in every case the sparks could be seen at the point of contact.

Second. The needle of a delicate astatic galvanometer was not sensibly deflected by the sparks, on an apparent current being caused to traverse the coils of the instrument.

Third. A small shred of cotton wool was not sensibly attracted or repelled by objects from which the spark might be obtained.

Fourth. The so-called retro-action of the spark was distinctly observed. On looping a wire back on itself, a decided spark was seen at the point of contact made by the end of the wire with any portion of the wire itself.

All the above results are in strict accordance with the known laws of electricity, as will appear hereafter.

To still further compare these results with those obtained by Mr. Edison, we dispensed with the use of the induction coil, and employed an apparatus similar to that described by him, viz.: An electro-magnet in connection with the battery already mentioned, the current of which was rendered intermittent by means of an ordinary interrupter. With this arrangement, a wire in contact with the core of the magnet yielded sparks having all the properties described by Mr. Edison.

From a careful reading of the published accounts of Mr. Edison and Dr. Beard, it appears that the alleged discovery of a new force is based on their failure to obtain from the sparks, indications of electrical charges or currents; or in other words, in the apparent absence of electric polarity. All the effects noticed, however, are readily explainable by reference to the presence of an instantaneous outgoing current, immediately followed by an incoming one, with the complete re-establishment of electrical equilibrium. When we bear in mind the enormous velocity of electrical currents of this character, probably some hundred thousand miles per second, we can readily understand that the flow and reversion of the current would take place in an exceedingly small fraction of a second; a space of time insufficient, were the current merely direct, to produce any decided divergence of the leaves of the electroscope or the needle of the galvanometer. *The presence of the inverse current, immediately following the direct*

current, would absolutely and necessarily prevent the exhibition of electrical polarity as exhibited in the motion of the electroscopes, galvanometers, and of similar instruments.

It is doubtless due to the fact that the direct and inverse currents are opposite in their effects, and therefore produce instantaneous electrical equilibrium, that Mr. Edison failed to obtain the characteristic twitching of frogs' legs, or the discoloration of iodized paper; for, although these results would unquestionably follow an electric current in one direction, their presence would be masked by the opposite effects produced by the instantaneously following inverse current.

The possibility of the existence of the direct and inverse currents, as above described, may be questioned: but when we bear in mind that the sparks can only be obtained by the interruption of the battery current, and that it is necessary to pass the battery current through a long coil of wire, conditions in every way favorable to the production of instantaneous induced or extra currents; the direct and the inverse currents follow as a matter of necessity; for the induced or extra currents in the coil of wire necessarily produce, in the core of the magnet and the metallic wire in connection therewith, an electrical current in one direction, instantaneously followed on the cessation of the induced or extra current; by a current in the opposite direction for the re-establishment of the electric equilibrium in the cores of the magnet.

It is a fact well known to all versed in electrical science that the induced current produced at the moment of making contact with the interrupter flows in the opposite direction to that produced on breaking the contact. This fact would in itself, exclusive of the above explanation, be sufficient to account for the production of inverse currents in the core of the magnet, when the interruption of the battery current was sufficiently rapid. Dr. Beard admits that the phenomena may be referred to a somewhat similar explanation, but the value he attaches to his supposition, may be judged from his subsequent adoption of the term "apolic force" as a preferable term to "etheric force."

It is matter of surprise to us that both Mr. Edison and Dr. Beard endeavored by careful insulation to eliminate in the apparatus employed by them the effects of induced electricity or induction, since it is a recognized fact in electrical science that the more perfect the insulation the more decided the effects of induction; of which, perhaps, no

better instance could be found than the care taken to thoroughly insulate the secondary coils in the induction on Ruhmkorff apparatus. In view of the above considerations, we feel warranted in the belief that all the phenomena noticed by Mr. Edison and Dr. Beard are explainable by the presence of inverse electrical currents of considerable quantity, but comparatively small intensity, instantaneously produced at the making or breaking of the battery circuit.

There was noticed during the progress of our experiments with the induction coil, the following curious phenomenon, which appears to us favorable to the explanations we have adduced. One of the poles of the coil was connected with a gas pipe, and the other with an insulated conductor of considerable surface in the room containing the Ruhmkorff core. This room is in connection by a telegraph wire with the chemical laboratory on the floor below, and with an earth circuited station, D, in another building, about five hundred feet distant in a direct line. On the interrupter of the coil being worked, a peculiar clicking sound was heard by both of us in the line wire in the chemical laboratory. The operator at D was requested to observe whether any unusual phenomena were noticed at his instrument. He at once telegraphed to us that a distinct "tinkling sound" was heard, which did not vary whether the ordinary battery current of the line was opened or closed. Since he did not know what to expect, his confirmation of our observation was very satisfactory. The production of the sound is probably referable to a rapid succession of molecular changes produced in the wire by the sudden reversion of its electrical states.

Central High School, Philadelphia, Dec. 11th, 1875.

NOTE BY THE EDITOR.—It will be observed that these results of Prof. Houston were produced by the use of unquestioned electricity, as obtained from the Ruhmkorff coil, and the fact of their exhibiting all the negative properties, as well as the apparent absence of polarity, which Mr. Edison appears to regard as the proof of the existence of the new force, goes to show that the assumption of a new force is simply gratuitous. The experiments made by Prof. Houston had for the source of electricity, a Ruhmkorff coil, but the reference in the original article of 1871, to a cylinder or plate machine, demonstrates that the source of electrical force, whether magneto-electric, frictional, or derived from a battery, was, in the opinion of Prof. Houston, immaterial. It follows that whatever there may be *remarkable* in the phenomena of so-called Etheric Force, was described by Prof. Houston, previous to *the discovery* of Mr. Edison.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.†

[Continued from Vol. lxx, page 427.]

In 1842, Zinin succeeded in converting nitrobenzol into aniline by the action of nascent hydrogen, and thus opened out an industrial region of unimagined extent. The era of the artificial dyes followed. It was soon perceived that many of these substances shared with indigotin the property of being decolorized by hydrogen, and thus zinc powder was introduced into calico-printing as a discharging agent, which, developing hydrogen in patterns where it is printed on, removes artificial coloring matters, *e.g.*, magenta.‡

A series of interesting observations showed, however, that the manner in which hydrogen is evolved is not without influence on hydrogenization. Whilst ammonium sulphide, and whilst acids under the influence of metals give up so much hydrogen to nitrobenzol as to form aniline, if other sources of hydrogen are employed the reaction is arrested half-way and intermediate products are generated. Herewith, therefore, nascent hydrogen escapes from our general consideration, and its technical application will be described in future parts of this report.

We return, therefore, to its applications as a source of heat and light. It has been briefly described in the section on oxygen how the oxyhydrogen blast was evolved from the experiments of Saron between 1780 to 1790, and how it was introduced in the manufacture of platinum in the middle of the present century by Deville and Debray. Since 1838§ Desbassains de Richemont found in hydrogen

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* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† From the *Chemical News*.

‡ The transformation of the colored salts of rosanilin into the colorless salts of leucanilin by means of zinc and hydrochloric acid was discovered by A. W. Hofmann in 1860.—*Proc. Roy. Soc.*, vol. xii, p. 2. The above application is due to Durand. See Schützenberger, "Traité des Matières Colorantes," vol. i, p. 491.

§ Karmarsch, "Geschichte der Technologie," 380.

mixed with air the means for the autogenous soldering of sheets of lead, and thus supplied the sulphuric acid manufacture with the fundamental condition of its growth, *i. e.*, permanent lead chambers of any desired magnitude. If, in places where coal-gas is readily procurable, this combustible is substituted for hydrogen in soldering lead many sulphuric acid chambers are not near gas-works, and in them hydrogen is still necessary for soldering. The same must be said on the application of hydrogen for the autogenous soldering of other metals and alloys, a process for which Winckler, in his convincing essay already quoted, predicts a great future. More recently, lead pans soldered in this manner nave been introduced in the manufacture of boracic acid in Italy. Numerous conflagrations, especially that of Canterbury Cathedral in 1871, and that of the Alexandra Palace on Muswell Hill in 1873, demonstrably due to the braziers full of fire used in soldering the leaden spouts, have lead, in England, to the proposal to solder leaden roofing and spouting, with hydrogen.

How far hydrogen is superior to other kinds of fuel appears from the following table. According to the experiments of Favre and Silbermann, 1 grm. of the following bodies, when burnt in water, gave the appended number of calories, *i. e.*, it raised, by 1°, the temperature of the given number of centigrams of water.*

Hydrogen	34·462
Carbonic oxide	2·403
Oil of turpentine	10·852
Stearic acid	9·716
Alcohol	7·814
Marsh-gas	13·063
Wood charcoal (burnt to carbonic acid)	8·080
Ethylen	11·858
Ether	9.028

The temperature of the flame does not, however, depend exclusively on the heat of combustion. The density of the burning body and the specific heat of the products of combustion must also be taken into account. Hence it comes that the temperature of the hydrogen flame in pure oxygen is about 6800°, in air about 2600°; the temperature of the flame of carbonic oxide in oxygen amounts to 7000°, in air about 3000°;† further according to calculation 1 vol. of hydrogen = 1 grm.

* A. Wurtz, "Dictionnaire de Chimie," vol. i, pp. 825, 82.

†Debray, "Sur la Production des Températures Elevées et sur la Fusion de la Platine." Lecons de Chimie en 1861, 65; Paris, 1862.

is capable of fusing 205 grms. of platinum, whilst the same volume of carbonic oxide can fuse 238 grms. of platinum (melting-point 2000°.) In practice, however, even under the most favorable conditions, as Deville and Debray determined in their researches on platinum, about half the heat is lost by conduction to the furnace and other surrounding matter, and the above authorities with 120 liters of hydrogen and 60 of oxygen succeeded in fusing only 1 kilo. of platinum instead of double the amount as calculated. Platinum can also be smelted and refined under similar circumstances with coal-gas. But for the more infusible metals of the platinum group, iridium, ruthenium, and their alloys, the hydrogen flame must be retained, which, if costlier than coal-gas, is cheaper than carbonic oxide.

In the use of gases as fuel the metal itself can be brought in contact with the flame, which is impracticable in case of carbon, and thus the great loss of heat is avoided which ensues when the crucible is heated from without. Their application renders it also possible to inspect the condition of the metal at any moment. In the metallurgy of the common metals these two advantages do not come into consideration. Carbon, moreover, is not only the cheapest but the most productive fuel,* and the application of hydrogen as a source of heat seems therefore limited to autogenous soldering and to the fusion of the most refractory platinum metals.

The property of platinum-black to ignite hydrogen, of which Dobereiner made a well-known and widely utilized application in his hydrogen lamp in 1823, has lost its practical importance owing to the discovery of friction matches.

The more intense and permanent was the interest which hydrogen created as a source of light.

As the luminous power depends on the temperature at which a solid ignited body is maintained the suggestion was near at hand to produce an intense light by means of this gas, in which an incombustible body was heated to whiteness. To this end the Scotch military engineer Drummond used in 1826 cylinders of caustic lime heated in the oxyhydrogen flame. The Drummond light has been widely employed, not merely in geodetic measurements and in lighthouses, which the inventor had principally in view, but also for projections of microscopic objects and photographic images on glass, or drawings upon

*The calculated temperature of the flame of Carbon in oxygen is 10,000°, from which has to be deducted the unknown amount of heat which at this temperature is lost by dissociation. See Debray, *opus citat.*

gelatine for demonstration in lecture-halls,* for disolving views, and chromatropes. In the American civil war it was used in sieges to light up forts.† The English war department has tried it in barracks in large halls and courts, in which‡ it is said to have proved cheaper than coal-gas, whils the smallest characters could be read at a distance of 90 meters from the source of light.

Since lime partially loses its luminous power by continued use, platinum-wire, magnesia, and latterly zirconia, have been employed in its stead.§

The above-mentioned applications of the hydrogen lamps are, however, of a very limited nature. To utilize it on the large scale for street lighting, the simultaneous use of oxygen has been laid aside, and cheaper methods of preparation have been sought for. For this purpose advantage was taken of Felice Fontana's method of decomposing water by means of ignited iron and ignited carbon, as proposed in 1780.‖ On the latter scheme Donovan founded his industrial preparation of hydrogen gas in Dublin in 1830. His process has been repeatedly described with modifications, referring in part to the needful apparatus, and in part to the diminution of the proportion of carbonic oxide. The presence of this poisonous gas was at first justly urged as an argument against the use of the "water gas." Langlois found that the mixture obtained—on allowing steam to pass over iron retorts filled with red-hot coke in Kirkham's apparatus—had the tolerably constant composition of 58 to 60 per cent. of hydrogen, 19 to 26 carbonic oxide, and 15 to 20 carbonic acid.

(To be continued.)

Carbonic Acid in Air collected by the Balloon "Le Zenith." By G. Tissandier (*Compt. Rend.*, lxxx, 976–978). By means of a reversible aspirator, having a capacity of 22 liters, the air was drawn through tubes containing pumice stone saturated with potash solution. The carbonic acid was afterwards expelled by sulphuric acid, and measured over mercury. It was thus estimated that at an altitude of from 800 to 890 meters, 10,000 volumes of air contained 2·40 of carbonic acid; and at 1000 meters, contained 3·00 volumes. The difference between these numbers is not greater than in the results obtained at the surface of the earth.

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* This Report, p. 14; also H. Vogel, *Ber. d. Chem. Gesell.*, iii., 901.

† Wagner, "Lehrbuch der Technologie." 9th edit., ii., p. 377.

‡ *Journal of Gas-lighting*, 1869.

§ See the work of Phillips, quoted above.

‖ *Mem. Soc. Ital.*, xv.

ON NOCTILUCINE, THE PHOSPHORESCENT PRINCIPLE OF LUMINOUS ANIMALS.*

By Dr. T. L. Phipson, F.C.S.

Member of the Chemical Society of Paris, and of the Royal Society of Medical and Natural Sciences of Brussels, etc.

In reviewing the various phenomena of phosphorescence, which are so numerous, both in the mineral world and in organic nature, it is not very difficult to convince one's self that in the great majority of well-observed cases belonging to the former, the production of light can be directly referred to electrical action, or to electrical action resulting from chemical action, and the latter mostly from oxidation.

As examples of purely electric action, may be cited the light produced in the formation and cleavage of crystals; the sparkling of boracic acid when cooling after fusion; the light emitted by benzoic acid during its sublimation; the flash of light that accompanies the cleavage of a plate of mica, when one fragment is found to be electro-positive, and the other electro-negative, immediately after the operation; the light emitted when quartz pebbles are violently rubbed together, which is accompanied by an odor of ozone; the flickering scintillations observed when a mixture of sulphate of soda and sulphate of potash crystallizes, when arsenious acid crystallizes, when crystals of sugar or nitrate of uranium are broken, and a very great number of similar cases which it would be far too long to mention here. In fact, the more the phenomenon is observed, the more general it appears to be throughout nature.

As examples of electrical action following on chemical action, may be cited the luminosity of phosphorus, of potassium and sodium, of arsenic, sulphide of antimony, and a considerable number of cases where oxidation, or other chemical action is intense. I have referred to all these in another place.†

In the organic world, with one exception, the luminosity of animals and certain plants can be with tolerable certainty referred to the production of the principle which I have termed noctilucine. The

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*Read before the British Association for the Advancement of Science, Bristol, 1875.

† "Phosphorescence; or the Emission of Light by Minerals, Plants and Animals." London, 1862.

one exception is when the production of light can be traced also, with the greatest probability to electrical action. This is evidently the case with the sparkling radiations which are occasionally seen round the flowers of the marygold and several other plants at a certain period of their growth, when the atmospheric conditions are favorable. The phenomenon is coincident with the rupture of the anthers and the ejection of the grains of pollen. We have other examples of a similar production of light resulting from the sudden rupture of plant tissue in dry weather.

Noctilucine is a peculiar organic principle, which appears to be very widely spread through nature. It is the cause of the light of the glow-worm, the scolopendra, the fireflies, the pholas, and numerous other luminous animals, both during life and for a certain time after death. The first allusion to the existence of this substance occurs in my note, "Sur la Matiere Phosphorescente de la Raie," published in the *Comptes Rendus* of the Paris Academy in 1860, where I have spoken of it as a peculiar organic matter, devoid of phosphorus, but shining in the dark like that element itself. It was found, by the most careful tests, to contain neither phosphorus nor phosphoric acid. It is again alluded to in my work on "Phosphorescence," published in London in 1862, (p. 103), and finally in my paper, "Sur la Noctilucine," in the *Comptes Rendus* of the Paris Academy for August 26, 1872, (p. 547). The same substance is noticed again, exactly one year later, (August 25, 1873), in the same publication by Professors Ch. Robin and M. Laboulene.

Noctilucine is not only the cause of the phosphorescence of dead fish and animal flesh of every kind, but it is secreted by living animals, such as the glow-worm, the scolopendra, the fireflies (*Elater*), the common earth worm, and by a very considerable number of others, amounting probably to many hundred distinct species, that are seen to shine in the dark. It appears to be produced also by certain living plants—*Agaricus*, *Rhizomorpha*, and *Euphorbia* (?)—and occasionally in the decomposition of vegetable matter (putrid fermentation of potatoes, etc).

At the ordinary temperature of summer in this climate, noctilucine is a fluid nitrogenous substance, slightly viscous or oily in appearance that can be mixed with water, but does not dissolve, though the watery liquid can be filtered; its specific gravity is slightly less than that of water; its color is white, when impure, yellowish white, and when decomposed becomes brown.

When recently extracted from a living or dead animal it invariably contains a certain quantity of water, and possesses a slight odor recalling that of caprylic acid; it is insoluble, or only slightly soluble, in alcohol and ether, but mixes with them and with glycerine. It is dissolved and easily decomposed by acids and alkalies, and when heated with potash it evolves ammonia.

Alcohol, ether, and especially mineral acids, extinguish its light very readily. When left for some days in contact with pure water, it enters into decomposition, and evolves after a time an ammoniacal odor of putrid cheese.

As long as it is moist, noctilucine absorbs oxygen and evolves carbonic acid; but, when left in the air, it dries up into thin, semi-transparent films, quite devoid of structure of any kind, and then resembles the substance called *mucine*, which has been obtained from garden snails and other Gasteropoda.

When recently obtained, noctilucine is highly phosphorescent, and this production of light is evidently due to oxidation in contact with the air. Numerous experiments leave me in no doubt of this. It will even shine in water when air is present in that liquid. As already stated, it is slightly soluble in water; at any rate, it mixes so intimately that the liquid, after filtration, is luminous in the dark when stirred, but as the oxidation of the noctilucine proceeds, the water becomes turbid or milky and ceases to shine; it soon after enters into decomposition, evolving first an odor of propylamine, and afterwards an odor of putrid cheese.

In oxygen gas, the light emitted by noctilucine is rather more vivid than in the air, but it is more brilliant still during a southwest wind that carries much ozone. The production of light ceases when oxidation is completed, but, when the slightest quantity of air adheres to it, noctilucine will shine for a little time in moist carbonic acid.

In the heat of summer, noctilucine occasionally gets separated from the bodies, living or dead, of various marine animals, in sufficient quantity to form a thin oily stratum on the surface of the water of stagnant pools or coves on the sea coast. This oily layer gives out light when stirred so that the air can come well in contact with it, the surface being completely oxidized and having ceased to shine. Near the pier at Dover, and at the back of the port at Ostend, I have seen many square yards of water covered with this film of noc-

tilucine in June and August; it contained few or no luminous animals, and in the evening shone when stirred. The same thin layer will form, in the course of twenty-four hours, on water in which noctilucine obtained from dead fish has been dissolved, or rather mixed; and I possess four observations of the same formation occurring upon urine. In all these cases light is emitted from the film whenever it is stirred so that it comes thoroughly in contact with the air; after repeated stirring when oxidation is completed, the light ceases to be seen.

According to some recent observations upon the fireflies of the West Indies, by Professor Charles Robin and Dr. Laboulene (*loc. cit.*) it appears very probable that noctilucine gives rise to uric acid, or urates of ammonia and soda, in its final decomposition, as these substances are invariably found in the phosphorescent organs. The characters of the luminous substance, as investigated by them in these exotic insects, correspond to those of the noctilucine extracted by me from fish, and from the glow-worm and scolopendra. These gentlemen have studied the anatomy of the luminous organs with almost as much care as Professor Paoli Panceri has studied these organs in polypes and other lower animals, in a series of remarkable papers read to the Royal Academy of Naples in 1872, and profusely illustrated.*

In phosphorescent animals noctilucine is secreted by a special organ, just as bile is secreted by the liver, and this luminous organ is as special in its character as is the electric organ of the *torpedo* or *gymnotus*. The substance is produced, and gives light, as fast as it is required. But noctilucine is also produced under certain conditions of temperature and moisture by dead animal matter, such as flesh, blood, and sometimes in urine. Whatever may be its origin, it always gives the same kind of light; the spectrum of this light really spreads from C to a little beyond F, when the phosphorescence is very vivid (as in the *Elaters* of the West Indies), but its brightest portion lies between the lines E and F, and in most cases this portion only is visible, and the light appears nearly monochromatic. It has no lines nor bands of absorption. As far as I have hitherto been able to examine it, noctilucine, whether extracted from dead fish,

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*The researches of these distinguished physiologists have confirmed most completely my earlier conjectures as to the special character of the luminous organs of phosphorescent animals, even those lowest in the scale of animal life.

from the glow-worm or the scolopendra, possesses the same chemical properties. It is secreted in a state of great purity by *Scolopendra electrica;* and in the month of September it is possible, by causing several of these myriapoda to run about on a flat glass dish with vertical slides, to collect enough of it to examine its principal characters. From the luminous organ of *Lampyris noctiluca*, and from the surface of phosphorescent fish, (stockfish, mackerel, herring, etc.), it can also be obtained, in a less pure form, by collecting on a damp filter the luminous matter, washed or scraped from the surface, or, better, by stirring the shining matter with water and allowing the liquid to stand in a narrow vessel till the next day, when the noctilucine will form a layer upon the surface that can be separated; but it is already partially decomposed.

The experiments I have made with this substance for several years past, whenever I have had an opportunity of observing it, lead me to the conclusion that it is of a basic or neutral, rather than an acid, nature; and, though I have not yet obtained it either pure enough or in sufficient quantity to investigate it very minutely, I believe that noctilucine belongs to the propionic series. It may, perhaps, hereafter be proved to be a cyanic derivative of propylic aldehyd, belonging to the same class of bodies as *leucine* (cyanhydric derivative of amylic aldehyd) or *creatine.* This would also tend to account for the final resolution of noctilucine into *urates* of soda and ammonia, which are almost always found in the luminous organs of various animals.

The secretion of noctilucine by the higher classes of luminous animals, such as the insects (*Elater*, *Lampyris*, etc.) and myriapoda, is, doubtless, to a certain extent, under the influence of the nervous system, which gives them the faculty of causing the light to cease. In this case the secretion is arrested for the time. (It has been long known that the eggs of the glow-worm shine for some time after they are laid, so that they also must contain a small quantity of noctilucine.)

In animals much lower down in the scale, such as the little *Noctiluca miliaris* of the English Channel, the polypes, medusæ, etc., it appears to me quite evident that there exists also a *special organ* for the production of noctilucine; and even here, where we find scarcely any indication whatever of a nervous system, the secretion of this luminous matter often appears to be subject to external influences.

London, October 28, 1875.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXXI. FEBRUARY, 1876. No. 2.

EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors, the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Safety Boilers.—Two explosions of the Howard tubulous boilers have recently occurred in England, resulting in loss of life and property, as usual from similar disasters to other kinds of boilers. The evidence before the coroner at the inquest for one of these explosions is reported in the London *Engineer* of December 31, 1875, to which paper, those who desire full particulars are referred. Mr. Lavington E. Fletcher, Chief Engineer to the Manchester Steam Users' Association, in his evidence says: "The Howard patent safety boiler consists of a number of pipes, in which the steam is generated, the pipes sometimes set vertically and sometimes horizontally, or nearly so."

As stated by Mr. Fletcher, there are two entirely different types of Howard safety boiler. The original construction consisted of a number of rows of 6, 8 or 10-inch vertical wrought iron tubes, 4 feet or

so in length, with upper ends closed (the steam being removed from the vertical tubes by a small pipe connection at the closed ends), and lower ends joined to lines of cast iron bed pipes, which lines of bed pipes were also joined together by a cross bed pipe at one end ; the fire was applied below the bed pipes and the heat made to circulate among the vertical tubes. This type of boiler was found to have the usual faults of a cast iron boiler when exposed to the fire: the castings would crack, none of the joints proved reliable, and those of the small steam pipes were especially troublesome, and another departure was made after three or four years' experience without much serious disaster. The second style of boiler, (which the prestige of advertising brought into immediate and extensive use in England), consisted of a nest of wrought iron tubes, slightly inclined from the horizontal line, of large diameter (8 to 10 in.) and 12 ft. or so in length ; the ends of these tubes were joined into "fittings" of cast iron, and the "fittings" were held together by through bolts of sufficient strength. The details of this construction it is not necessary to describe, but only to say that the completed "safety boiler" was a number of rigid vertical grids of five pipes each, the number of grids employed giving the width of the boiler ; and the separate sections were joined together by a cross bed pipe at one of the bottom corners, (the front and lowest one), and by small steam pipe necks to a steam main at one of the top corners (the back and highest one). This last construction obviated some of the constant leakages and other troubles of the former one, and removed the objection of a cast iron bed pipe, exposed to the fire ; but while both kinds were deficient in circulating provisions for the heated water and insufficient in evaporating surface, the latter was radically and dangerously so ; besides, from the grid shape of the sections, and the effect of unequal expansion, (when the bottom tube become overheated, by the failure of the circulation, and the water lifted from it), was to cause, or at least risk, the fracture of the fittings or of the tubes themselves. The liability to these accidents was of course diminished to some extent by the use of large tubes in the Howard safety boiler, but on the other hand the disastrous effect was increased by their unyielding, unelastic character when the bottom tubes should chance to empty.

The water hammer which follows the emptying (by the expansive force of steam formed next the fire surface) when the expanded superheated steam is absorbed into the returning columns of water, is

productive of shocks, which cannot be appreciated by any one who has not witnessed the behavior of an active hot water apparatus when its circulation from leakage or removal of water is broken in the continuity of the flow of its upper pipe. The convulsive discharges of water, the shock of contact of one mass of water with another, (in the bed pipe where no air is interposed), the violence of the actions and reactions, are something frightful to observe; and when one considers the quiet regularity of the circulation a few moments previously, although the furnace may have been consuming at the rate of 10 or 12 lbs. of coal per square foot of grate per hour, and its vehement, almost explosive condition following the failure to circulate, and applies the phenomena to the transmission of heat by a current of water from the fire surface of the bottom of a boiler to the water surface at the top (in place of from a fire surface to another surface), he will then discern the conditions of boiler circulation. These considerations would give a possible, if not probable, cause for the explosion which occasioned the inquest. The defect of iron which appeared, and was assigned by the defence as a reason, may have had a part in the accident, but it is questionable whether the blistered iron was an original defect or merely a result from overheat. From an experience in numerous come-downs in sheets over the fire, where the presence of tubes or of a flue above them, had prevented the adequate supply of "return" water, the writer feels confident in asserting that the apparent blisters, in many cases at least, are merely a development of the internal condition of the iron. Boiler plates are tested for strength in two directions. Plates rolled from homogeneous slabs or cross piles, or cross piled billets, will exhibit from 10 to 15 per cent. greater strength in the direction of the rolling or principal extension in forming the plates. But tests of strength in the direction of the thickness of the plates have never yet been made, and it is at once admitted that the lamilar action of rolling must stratify the sheet and affect the cohesion of the strata very materially. The tendency of a plate to laminate (not necessarily to blister) under the influence of excessive heat on the outside, with repeated reductions of temperature on the inside, is certainly a very great one. * * * *

There are boilers in which the main circulation takes place in the bed of nearly solid water, (underlying the layer of foam, or of mingled water and steam bubbles); the development of steam bubbles commencing at that elevation where the pressure of water column relieves the

heated water. The common upright tubular boiler is a case in point and there are in use one or more boilers of the tubulous character with horizontal tubes in which the separated circulation subsists. The original "Howard safety" depended on a similar circulation in its large upright tubes; but the second type, with its inclined (nearly horizontal) tubes appear to have had particular arrangement to prevent quiet circulation—it was *intended* that the steam-evolving water, after giving out its heat and steam, should lift high enough to over-run a bridge before it was to be allowed to return. * * *

This line of reasoning could be pursued further, with, perhaps, advantage to some readers, but it clearly belongs to other pages of the Journal, and it is only needful to assert now, that there are numbers of men in England and in this country, engineers or professors, who have been, and are, well enough acquainted with the practical construction of boilers, (circulating or otherwise), the pheneomena of ebullition and the laws of heat, to have expressed opinions as decidedly three years ago as they can now, after numerous disasters have happened. It was perfectly well known that the things were as complete traps, as any figure of four that was ever set. It was a mere question of time when a little extra firing, or an unusual demand for steam supply should overcome the columns of water, and that, in perhaps one case out of ten in such casualties, a catastrophe would ensue.

This Howard safety boiler is not the only one of the group which has needed criticism, supervision or restriction from use. Within three years, a safety boiler, yet more liable to accident and more dangerous when it occurred, has exploded in this city on its first trial, and the disaster was also attended by loss of life as well as property. And our City Boiler Inspector reports to Councils that there are other boilers of similar "safety" character, in use in Philadelphia.

It must not be supposed that these objections attach to all boilers, or to all tubulous boilers, or to all new kinds of boilers. There is a possibility of attaining a measure of safety from disastrous explosions in the construction of boilers in small and multiplied parts. These boilers cannot be said, generally, to offer any especial protection to attendants or firemen, (in truth some of them have been criminally dangerous in this regard), but they do present an immunity to the public, and to the owner, from extensive damage following an accident. The nearly insuperable troubles of construction, the diffi-

culties of cleaning, and the consequent rapid deterioration of these boilers as a rule, has kept them steadily in discredit, and of the number which have been introduced within twenty years, few, if any, exist to-day of three years' existence in unmodified forms; while inventors (with and without knowledge or prudence), are daily adding to our patent office records, and occasionally adding also to the disaster column of the newspapers.

Admitting this premise, the question which the boiler user, or the citizen whose property or life is endangered, naturally asks, is—Why is not the public attention called to these dangerous boilers? Simply because it is not only nobody's business to do it, but because it is the business of many people not to do it. Or replying by another question: What right has any person to express uncalled for, derogatory opinions to the great damage or loss of an inventor? especially when such opinions may be erroneous.

The laws of trade in steam boilers, do not differ from others—*Caveat emptor*, buyer beware. The advertisement is paid for, and it is to be hoped that it is all true, even to the word "safety," (which *may* imply a safety to those who let the boiler alone). The *purchaser* is fully instructed by the salesman or agent in the laws of heat, and their application to the particular safety devices, until his own reason is satisfied to the utmost. Under these circumstances, an explosion afterwards, or even a failure is borne with equanimity, and the result becomes one of those profitable investments in mechanical knowledge known as experience. Seriously, the only relief from these accidents to be looked for, is when the public shall put more reliance in sound professional advice, (not circulars), and less upon the advertisements of interested projectors or salesmen.

This conclusion is admitted to be somewhat inconsequent so far as protection of the citizen or employee is concerned, but the question of the compatability of a public censorship with the rights of inventors and the progress of mechanism—of mechanical predestination and free-will—is too broad to be discussed at this time; and having presented to our readers some of the aspects of the safety boiler question, its further consideration may be deferred until called for by the expression of public opinion in other prints.

Note.—The Tables referred to in article on "Trials of Steam Machinery," will appear with March number of JOURNAL, as a supplement.

Franklin Institute.

Hall of the Institute, Jan. 19, 1876.

The stated meeting was called to order at 8 o'clock, P.M., the President, Dr. R. E. Rogers, in the chair.

There were present 146 members and 11 visitors.

The minutes of the last stated meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting the following donations were made to the library:

Second Geological Survey of Pennsylvania, 1874. Preliminary report of the mineralogy of Penna., by F. A. Genth, with an appendix on the hydrocarbon compounds, by S. P. Sadtler. Harrisburg, 1875. From G. W. Hall. 2d copy from A. K. Dunkel.

Special Report on the Petroleum of Pennsylvania. Its production, transportation, manufacture and statistics, by H. E. Wrigley, with maps and illustrations. To which are added a map and profile of a line of levels through Butler, Armstrong and Clarion Counties, by D. J. Lucas. Also a map and profile of a line of levels along Slippery Rock Creek, by J. P. Lesley. Harrisburg, 1875. From G. W. Hall.

Annual Report to the Stockholders of the Pennsylvania Steel Company, with plates and supplement. From the Company.

Annual Report upon the Improvement of Rivers and Harbors in New Jersey, Pennsylvania and Delaware, in charge of J. D. Kurtz, being Appendix X of the Annual Report of the Chief of Engineers for 1875. Washington, 1875. From J. D. Kurtz, Lieut. Col. Eng.

Second Geological Survey of Pennsylvania, 1874. Special report on petroleum of Penna., etc., by J. P. Lesley. Harrisburg, 1875. From A. K. Dunkel.

The Vienna Exposition. Report of the Philada. Commission to Vienna, J. E. Mitchell, President. From the Commission. Philadelphia, 1875.

Rules and Decisions of the General Assembly of Penna., etc., etc., by J. A. Smull. Harrisburg, 1875.

Auditor General's Report on Railroads, Canals and Telegraphs, 1873. Harribusrg, 1874.

Reports of the Inspectors of Mines of the Anthracite Coal Regions of Penna. for the year 1874. Harrisburg, 1857.

Commonwealth of Penna. Second Annual Report of the Bureau of Statistics of Penna. for the years 1873–74. Harrisburg, 1875.

Report of the Commissioners appointed to investigate the Bituminous Coal Mines of Pennsylvania. Harrisburg, 1875.

Commonwealth of Penna. Second Annual Report of the Bureau of Statistics of Penna. for the years 1873–74. Part II, Labor Report. Harrisburg, 1875. From G. W. Hall.

Revised List of the Vertebrated Animals now or lately living in the Gardens of the Zoological Society of London. Supplement containing additions received in 1872, '73 and '74. Also Parts 2 and 3 of proceedings. From the Society.

Miltheilungen der K. K. Geographischen Gesselschaft in Wien, 1874, Vol. 17. From the Society.

Fifty-fifth Annual Repart of the Managers of the Apprentices, Library Company of Philada, 1875. From the Library Company.

Second Geological Survey of Pennsylvania, 1874. Report of Progress in the Venango County district, by John F. Carl. Observations on the Geology around Warren, by F. A. Randall. Note on the comparative Geology of Northeastern Ohio, and Northwestern Pennsylvania, and Western New York, by J. B. Lesley. Harrisburg, 1875.

Report of Progress on the Brown Hematite Ore Ranges of Lehigh County, with a description of the mines lying between Emans, Albnrtis, and Fogelsville, by Fred'k Prime, Jr. Harrisburg, 1875.

Second Geological Survey of Penna., 1874–5. Report of progress in the laboratory of the survey at Harrisburg, by Andrew S. McCreath. Harrisburg, 1875. From the Board of Commissioners.

Eighty back numbers of the JOURNAL OF THE FRANKLIN INSTITUTE. From J. T. James, 1023 Arch St., Philada.

The Elements of Graphical Statics and their applications to framed structures, with numerous practical examples of cranes, bridge, roof and suspension trusses, braced and stone arches, pivot and draw spans, continuous girders, etc., 2 vols. Text and plates by A. Jay Du Bois, C.E. From John Wiley & Son, Publishers, New York.

Minutes of Proceedings of the Institution of Civil Engineers, with other selected and abstracted papers. Vol. 42, Session 1874–5, Part 4. London, 1875. From the Society.

Circular of Information of the Bureau of Education, No. 7. 1875. Constitutional provisions in regard to education in the several states of the American Union. Washington, 1875. From the Bureau of Education, Washington, D. C.

British Patent office publications for the weeks ending February 27th and March 6th ; also from March 20th to November 12th, 1875, inclusive. From the Commissioner of Patents, England.

Commonwealth of Pennsylvania. Official Legislative Directory, Session of 1876. Harrisburg, 1875.

Annual Report of the Secretary of Internal Affairs of the Commonwealth of Pennsylvania, for the year ending Nov. 30th, 1875. Part I. Land Office, Harrisburg, 1875.

Annual Report of the Superintendent of the Soldiers' Orphans of Pennsylvania, for the year 1875. Harrisburg, 1875.

Common Schools of Pennsylvania. Report of the Superintendent of Public Instruction of the Commonwealth of Pennsylvania for the year ending June 1st, 1875. Harrisburg, 1875. From Geo. W. Hall.

Department of the Interior; U. S. National Museum No. 1; Bulletin of the U. S. National Museum, No. 1; Check List of the North American Batracha and Reptilia, by E. D. Cope. Washington, 1875.

Department of the Interior, U. S. National Museum No. 2; Bulletin of the U. S. National Museum, No. 2: Contributions to the Natural History of Kerguelen Island, by J. H. Kidder, M.D. Washington, 1875.

Smithsonian Miscellaneous Collections, 238. List of the institutions, libraries, colleges and other establishments in the United States in correspondence with the Smithsonian Institution. Washington, 1872.

Smithsonian Miscellaneous Collections, 243. List of foreign correspondence of the Smithsonian Institution. Corrected to January 1872. 4th edition. Washington, 1872. From the Smithsonian Institution, Washington, D. C.

Circulars of Information of the Bureau of Education, No. 8, 1875. Schedule for the preparation of students' work for the Centennial Exhibition, etc. Washington, 1875.

The Actuary also reported the following action: The award of the Scott Legacy Medal and Premium to C. Tyson for his machine for uniting the soles to boots and shoes, and the Elliott Cresson Gold Medal to Dr. W. G. A. Bonwill for his electro-magnetic mallet for dental purposes, and recommending that the use of the Lecture Room on June 13, 14, and 15, next, be tendered to the American Society of Civil Engineers for the purpose of holding its annual convention.

The President presented the annual report of the Board of Managers, as follows, which was adopted:

Report of the Board of Managers to the Franklin Institute of the State of Pennsylvania.

Your Board of Managers beg to present the following report:

During the year 1875 there have been added to the list of members one hundred and forty, and removed from it by resignation, twenty-four, leaving an increase to the entire number of one hundred and sixteen.

The Report of the Treasurer herewith submitted as a part of the minutes of the Board, furnishes the following exhibit:

Balance on hand Jan. 1st, 1875, .	$61,336·09
Receipts during the year, . . .	27,907·95
Total, ...	$89,244·04
Expenditures and investm'ts during the year,	87,025·39
Leaving a balance on hand Jan. 1, 1876,	$2,218·65

The Journal of the Institute, which is under the management of the Editor and the Committee on Publication, has been for the year nearly self-sustaining. Including the amount previously on hand, there is a balance to its credit.

During the year the following medals have been awarded:

Elliott Cresson Gold Medal.

To Joseph Zentmayer, of Philadelphia, for improvements in Microscopic Objectives.

To Chambers Brothers, of Philadelphia, for improvements in Book Folding and Pasting Machines.

To Powers & Weightman, of Philadelphia. for the production of Citric Acid and the cheaper alkaloids of Cinchona Bark.

To Bullock Printing Press Co., of Philadelphia, for Bullock Printing Press.

Scott Legacy Premiums and Medals.

To John G. Baker, of Philadelphia, for Rotary Pressure Blower.

To Hutchins & Mabbitt, of Philadelphia, for Tilting Chair.

To J. Morton Poole & Co., of Wilmington, Del., for improvements in Grinding Calender Rolls.

To T. J. Rorer, of Philadelphia, for Union Belting.

To E. A. Goodes, of Philadelphia, for Sewing Machine.

To John E. Prunty, of Wilmington, Del., for Automatic Relief Valve for Steam Fire Engines.

To Geo. Wale & Co., of Hoboken, N. J., for College Lantern.

To H. R. Heyl, of Philadelphia, for wire fastened Paper Boxes.

To Wilcox & Gibbs Sewing Machine Co., of New York City, for Automatic Tension and other improvements in the Wilcox & Gibbs Sewing Machine.

To R. B. Goodyear, of Philadelphia, for Box Motion for Looms.

To Job A. Davis, for Vertical Feed, applied to Davis' Sewing Machine.

To Sholes & Glidden, of Philadelphia, for Type Writer.

To B. Tatham and J. W. Brittin, of New York, for Safety Catch for Elevators.

Drawing School.

It is with much satisfaction that the Board are able to report the steady growth of the night drawing school, under the auspices of the Institute.

During the Spring term there were in attendance eighty-one pupils, and during the Fall term, one hundred and fifty-three, being in the aggregate a large increase over previous years, a fact which furnishes evidence of the good work the Institute is accomplishing in promoting one of the best ends of its organization.

Lectures.

Courses of interesting and instructive lectures have been given during the interval between the beginning of November and the end of December of the year, on the following subjects:

On Acoustics, by Prof. E. J. Houston; on Mathematics, by Prof. D. D. Willard; on Gas Lighting, by Prof. W. H. Wahl; on Mineralogy, by Mr. T. D. Rand; and a special one for "young people," on "Experimental Science," by Prof. Houston.

Monthly Meetings of the Institute.

The attendance at the monthly meetings of members and strangers has much increased during the year, and interesting communications and noteworthy inventions and novelties have been presented and discussed on those occasions.

Alterations of the Hall.

Since the last Annual Report of the Board of Managers, the committee which had been authorized to act in the premises, have caused to be made several useful changes in the Institute Hall.

These changes have consisted in removing one of the common stairways; in enlarging the library room, and adding offices on that floor, in considerably increasing the capacity of the drawing school rooms; and in introducing a better system of heating and ventilation of the building.

Library.

With a better condition of the finances, resulting from the success of the exhibition, held between October 6th and November 12th, 1874, the Library Committee have been enabled, under authority given it, to improve considerably this valuable feature of the Institute,

by the purchase of new books, and binding and giving shelf room to many volumes hitherto almost inaccessible.

It is believed that the members generally, and certainly the public at large, are not aware of the treasure of practical knowledge contained in this collection, which has had its growth through the period of a full half century.

Besides whole series of most of the scientific periodicals of the day, it contains volumes upon nearly every practical and manufacturing art, and is at once a source for reference, invaluable to the scientific investigator, the inventor and the artisan, each seeking information in the line of his pursuit.

A statement of the condition of the library will be presented by the Committee on the Library.

The report of the Committee on Models will be read at this meeting, and will show what has been done in that connection.

In view of the facts herein set forth, the Board of Managers feel that they can cordially congratulate the Institute upon its increased prosperity and its promising prospects in the future.

All of which is respectfully submitted.

By order of the Board.

R. E. Rogers, *President.*

The Committee on Library presented the following report, which, on motion of Mr. Sellers, was adopted, and the Secretary was directed to convey to Mr. Ransom the thanks of the Institute, as therein recommended:

The Committee on Library respectfully report that regular meetings have been held during the year, which have been well attended.

An appropriation of $5000 was made by the Board of Managers, on January 15th, for the purchase of books; and the work of making selection at once began; but, in the absence of a correct catalogue, it was found difficult to make the proper selection, and consequently only $1394.41 of this amount has been thus far expended. The purchases made were carefully selected, and a large number of very valuable works have been added to our collection. The necessity of a new catalogue of the library has long been felt, and its preparation has only been postponed for want of funds, but that difficulty being overcome, its preparation was begun in earnest, and Mr. Geo. Corliss, a gentleman of considerable experience in such matters, was engaged for the work, and the catalogue is now ready for the printer.

The labor involved was greatly increased by the necessity of rearranging the books on the shelves, which arose from the fact that

the classification of the books on the shelves had become very imperfect from the large increase of the number of volumes since the original arrangement. The rearrangement of the books has been carefully done, not only with the view to the classification of subjects, but also to the probable increase for some years.

During the past summer the library room has been enlarged by the removal of the south staircase and a portion of the partition, so as to throw about three-fifths of the entry into the library room, and bringing it in direct communication with the two front rooms on the same floor; one of these rooms, and also the room formerly occupied by the Actuary, were appropriated to the use of the library.

The book cases were increased about fifty per cent., the whole room painted, and lighted with a row of chandeliers along the centre, and the floor covered with matting.

At the beginning of the year there was on hand a balance of $562.07 of the fund bequeathed to the Institute by Mr. A. S. Roberts, for the purchase of books, which has all been expended, and the books properly labeled.

A strong effort has been made to complete the set of British Patent Specifications and with such good results that there are now comparatively few missing ones. In this effort the committee have been greatly aided by Mr. Fred'k Ransom, of London, Eng., who visited the Patent Office, and otherwise used his personal influence in our behalf, and to him the committee consider the thanks of the Institute are due.

There was on hand January 1st a fund of $455, raised by subscription some time ago for binding British patents, and with this they have been bound as far as the series was sufficiently complete, leaving a balance still on hand of $186.

The following additions to the library were made during the year:

Donations of Bound Volumes, ...		44
Number of Volumes purchased, ...		272
No. of Volumes of Exchanges bound, . .		356
No. of Volumes added to the catalogue which were previously in the library, ...		236
Volumes of British Patent specifications bound,		650
78 abridgments of British Patent specifications bound in volumes, ...		49
Total No. of bound Vols. added to catalogue,		1607
Donations of pamphlets, ...	158	
Volumes rebound, ...	126	

The use of the library by members has been much greater since the improvements, and cannot fail to be still farther increased upon the completion of the catalogue.

CHAS. BULLOCK, *Chm. Com. on Library.*

The Committee on Models presented their report, as follows, which, on motion, was adopted:

The Committee on Models respectfully report that there have been held during the year one special and six stated meetings, which, however, were not very fully attended.

The necessity for more room for the drawing school made it desirable to remove the partition between the model and school rooms and the middle row of tables, the models being distributed in other portions of the room, and thus adding a considerable space to the school room.

At the beginning of the year the model room was in a very disordered condition, large quantities of *debris* of exhibition, and refuse material used about the Institute being stored in it. The models were much scattered and a large number of them in pieces.

The members of the committee found it impossible to give their personal attention to the work of clearing out the foreign matter and arranging the models, and therefore at the stated meeting, in March, a resolution was adopted asking the Board of Managers to appropriate $100 to be expended in this work. This appropriation was made (as also a subsequent one of a like amount), and an engagement was made with Mr. L. L. Cheney, who, under the direction of the Secretary and the committee, selected out and removed the useless material, assembled together the parts of models as far as possible, and made some progress in arranging them.

Although the collection of models is not large, there are quite a number that are of great historical value, but it is to be greatly regretted that the book in which they are registered is lost. It is proposed to make a new register and to collect such information regarding them as can be obtained, and to this end the committee recommend that all members of the Institute be requested to send to the Secretary such facts as they may be in possession of, regarding them. This work was suspended because of the alterations and repairs to the building, and has not since been resumed because of the pressure of other work on the officers and employees of the Institute, but the committee recommend that it be continued to completion.

C. CHABOT, *Chm. Com. on Models.*

Dr. H. W. Adams read a paper on the use of steam in burning bricks.

The Secretary's report embraced Edson's Time and Pressure Recording Gauge; Buzby's high pressure dissolver for Oxy-Hydrogen Lantern; Colburn's Porous Evaporator; Shinn's Rail Joint; Simpson's Combination Lock, Lever and Strap for Trunks; and Tingley's Steam Canal Boat.

Under the head of deferred business, the subject of the election of a trustee to the Pennsylvania Museum and School of Industrial Art was taken up, and Mr. Coleman Sellers nominated Mr. J. B. Knight; and no other nomination being made, on motion, Mr. Knight was declared elected.

The tellers of the annual election held this day presented their report, which, on motion of Mr. Mitchell, was accepted and the President declared the following members elected:

President, Robt. E. Rogers, M.D.
Vice-President, J. E. Mitchell.
Secretary, J. B. Knight.
Treasurer, Fred'k Fraley.
Managers to serve three years, Wm. Sellers, Hector Orr, J. Vaughan Merrick, Henry Cartright, Cyrus Chambers, Jr., H. W. Bartol, Jas. Hunter.
Auditor, Samuel Mason.

The eighth highest number of votes for managers having been cast for two persons, it was decided to be a tie and only seven members of the Board were declared elected.

Mr. J. E. Mitchell offered the following, which was adopted:

As one by one our of members fall from our ranks, it becomes our duty that some record should be made of our appreciation of their usefulness as members of this Institute, and of our respect for their memory as honored and public spirited citizens.

On the 21st of December, 1843, Mr. Geo. Hall became a life member of the Franklin Institute. As early as the year 1830, he was extensively engaged in the manufacture of silverware, as a member of the firm of Boardman & Hall. In 1833, he was called to occupy one of the most responsible positions in the coinage department of the United States Mint, which, by his strict integrity of character and close attention to his duties, enabled him to hold through the various changes in the administration of the mint until the year 1863, when the infirmities of advancing years compelled him to resign.

Mr. Hall died on the first of October last, in the 78th year of his age, respected and mourned by a large circle of friends; therefore,

Resolved, That the Secretary is hereby directed to place on record this testimonial of our respect for the memory of our departed member, and that a copy of the same be sent to his family.

Mr. Hector Orr presented the following preamble and resolution, which, on motion, were adopted.

WHEREAS, A Centennial Celebration characterized by an exhibition of industrial products, originally suggested by this Institute, bids fair to become one of the leading accomplishments of the age—and

whereas its international features have been established by a hearty recognition of our appeal by most of the nations of the world; therefore,

Resolved, That we respectfully ask the national government to authorize forthwith an appropriation of money sufficient to complete this great work.

On motion, the meeting then adjourned.

J. B. Knight, *Secretary.*

Centennial Supplements to the Journal.—It is proposed to publish from time to time, as material of suitable character may be presented, a series of supplements to the Journal, which shall contain articles describing machinery, apparatus or other subjects of interest to science or the arts. These supplements will have the book form of the Journal so as to become a part of the library collection for future reference. They will be furnished to the regular subscribers for the present year without charge. It cannot now be stated to what extent this means of circulating unprejudiced and impartial description of novelties or standard works may be availed of by the exhibitors, but it may be reasonably anticipated that many of them will regard the proposition of the committee on publication and the editor with favor, and that both the readers of the Journal, and the cause of scientific information receive advantage from the supplement. For further information on this subject, we refer to the Prospectus in the advertising form of this number.

The Manufacture of Tubes of Large Size.—The National Iron Tube Company, whose works are situated at McKeesport, in this state, have recently made welded wrought iron tubes so large as 15 inches in diameter. For the boilers of Western river steamboats, the substitution of welded for riveted flues will be a great gain in strength and consequent safety, while the reduction of weight from avoidance of laps and rivets enables this improvement to be effected without addition to the total cost. The eventual substitution of wrought for cast iron pipes and of welded tubes for riveted ones seems to be merely a question of a supply at moderate prices, to reresult from the improvement of machinery and furnaces.

Note.—The two articles which will be found on other pages of this number of the Journal, on "Ring Spinning" (F. H. Silsbee) and on "The Use of the Microscope in Analysis" (Frank W. Very) are theses of the advanced students of the Massachusetts School of Technology.

Bibliographical Notice.

Report on Building Stones.—By Maj. Gen. Q. A. Gilmore, Lieut. Col. Corps of Engineers U. S. A. 42 pp. D. Van Nostrand, New York. Reprint abstract from official report to the Chief of Engineers.

This is one of a series of publications of Gen. Gilmore upon materials used in construction, all of which are of extreme value as books of original information, collected into forms suitable for use and reference by the practical engineer. A discussion on the theory of elasticity of solid bodies, as applied to building stones is perhaps not so complete from a mathematical point of view as could be wished by the student, but it is ample for the purpose of argument in disabusing the constructing engineer or workman of idea that material under compression is only under stress in the line of the axis of compressive force, and the writer takes decided exception to the words. "It need hardly be said to engineers that such strains have existence only in the pages of mathematical applications," for it is in those pages that the contrary assertion is especially laid down. The examples taken of granite, marble, sandstone, are available for American practice, and will be taken as authoritative in the construction of piers or foundation walls hereafter. Some remarks are made as to the effect of interposition of material of lower or high elasticity of form upon the surface of the cubes of stone which were tested to fracture, but the mathematical propositions involved are not considered, nor are the effects upon ultimate strengths fully elucidated. No notice is taken of the impairment of strength by compression between surfaces of *less* size than those of the body under test, nor does the investigation embrace suddenly applied loads or attempt to measure the effects of blows either of falling or moving bodies. A modulus of elasticity of these stones, and their expansion, conductivity and other effects of heat, would be an excellent addition to the knowledge of the engineer. The publication of such memoirs in separate book form is a great convenience for the library, and this work is worthy to be one of an engineer's collection.

We wish to call attention to another publication of Van Nostrand, the "*Eclectic Engineering Magazine*," with an especial reference to a valuable article on the steam space in passages of the Woolf engine, translated from the *Bulletin de la Soc. Industriel de Mulhouse*—O. Holauer, which appears in the January and February numbers. This article had been selected for translation for the Journal of the Franklin Institute, but its prior appearance in a magazine so well known to our readers, renders another publication unnecessary.

Civil and Mechanical Engineering.

COTTON MANUFACTURE AND THE RING FRAME.

By F. H. Silsbee.

It may not be out of place to make a hasty review of the progress which has been made in the manufacture of cotton, and of the processes through which it has to pass, to transform the crude fiber into the finished cloth, before taking up the more immediate subject of this paper.

Cotton is the downy fibrous substance attached to the seeds of the various species of Gossypium, (a genus of plants of the order Malvaceæ), of which there are three principal varieties, namely: the herbaceous, the shrub, and the tree cotton, and of these the herbaceous is the most important. Some include in it all the varieties cultivated in the United States, but others refer the long-stapled sea-island cotton-plant to the arborescent division. The cotton raised in the United States, however, is usually considered to consist of two varieties, namely: the "sea-island," or "black seed cotton," which is long-stapled, and the "upland," or "green seed cotton," which is short-stapled.

The largest proportion of the cotton manufactured comes from the southern part of the United States, although large quantities are raised in the East and West Indies, Surinam, and Egypt. The cultivation of cotton in the United States was not carried on to any great extent until towards the close of the last century. Mr. Timbs in his book on "Wonderful Inventions," has a paragraph which shows how important the exportation of cotton from this country to England was in 1784. In that year, he says: "An American vessel arrived at Liverpool, having on board eight bales of cotton, when they were seized by the custom-house officers of that port, under the impression that they had been imported from some

other country, as they had never before seen American cotton. In 1785 only five bags were imported, and next year six; such were the small beginnings of that immense trade, which now gives employment to millions on both sides of the Atlantic." The superiority of American cotton however, especially of the sea-island variety, soon caused a great demand for it, and in 1855, the total value of the American cotton crop was estimated at $140,000,000. This increase in the production of cotton was, besides its good qualities, in a great degree owing to the increased facilities for manufacturing it, and also for ginning it or separating the fiber from the seeds.

In a paper read by Mr. Atkinson, at the last meeting of the New England Cotton Manufacturers' Association, it is shown that the property which the cotton fibers have of holding together, when the yarn is spun, is not due to any scale or beard, as in the case of wool, but to the fact that the fibers have a natural twist in them, and therefore, when the cotton is pressed and twisted together, these twists are forced into each other, just as two spiral springs would be if pressed together.

The use of cotton for the manufacture of cloth was known to the inhabitants of India and Egypt over 3000 years ago, and mention is made of it by Heroditus about 450 B. C. Cotton was known in Spain in the twelfth century, and was eventually introduced into England; but, except for candle wicks, it was not much employed there before 1641, when it was used at Manchester in making fustians and dimities.

The great starting point of the cotton manufacture in England may be dated from the year 1760. In that year, the Society of Arts offered a premium for the greatest improvement in the common spinning wheel, and afterwards offered £100 for a machine that would spin six threads of wool, cotton, flax, or silk at the same time. In the year 1760, or soon after, Hargreaves, a Lancashire weaver, invented the carding machine, which was somewhat similar to that now used; and in 1767 he invented the spinning jenny, which at first contained eight spindles, but the number was afterwards increased to eighty. In 1769 the method of spinning by means of fluted rolls, through which the cotton is passed, in order to draw out the "roving" to the required thinness, was introduced by Arkwright, who first put it in a practical shape, although the invention is claimed for Paul and Wyatt. This machine was at first driven by water-

power, and hence was called the water frame. In 1779 Samuel Crompton invented the mule, which after several unsuccessful attempts, was made self-acting, about forty years ago. It was a vast improvement over any of the previous spinning machines, as it required less power and was capable of spinning much finer threads. About 1784 Cartwright invented a rude sort of power loom, which, like all the other inventions, has since been much improved. About this time also, the "dresser" was invented, by means of which the yarn is sized, in order to make it stronger for the operation of weaving. Since this time, very few radical changes have been made in the process of making cotton cloth, with the exception of the ring frame, which I shall mention farther on; although of course the machines have been so much improved as to appear almost like new inventions. It is curious to notice the increase in the number of factories, brought about by the improvements in the machinery. In 1780 there were only twenty cotton factories in England, and in 1790 there were one hundred and fifty. In a little book by Mr. Batchelder, entitled the "Introduction and Early Progress of the Cotton Manufacture in the United States," there is a great deal of interesting information, and many curious statistics given in regard to the early history of the cotton manufacture, both in this country and in England; but I have only room here to mention some of the most important and interesting points. The first factory for the manufacture of cotton, built in this country, was commenced at Beverly, Mass., in 1787. In Washington's diary, dated Friday, October 30th, 1789, is the following description of the Beverly factory: "After passing Beverly two miles, we came to a cotton manufactory, which seems to be carrying on with spirit, by the Cabots (principally). In this factory they have the new invented carding and spinning machines. One of the first supplies the work, and four of the latter; one of which spins eighty-four threads at a time, by one person. The cotton is prepared for these machines, by being first (lightly) drawn to a thread, on the common wheel. There is also another machine for doubling and twisting the threads for particular cloths; this also does many at a time. For winding the cotton from the spindles and preparing it for the warp, there is a reel, which expedites the work greatly. A number of looms (fifteen or sixteen) were at work, with spring shuttles, which do more than double work. In short, the whole seemed perfect, and the cotton stuffs which they turn out ex-

cellent of their kind—warp and filling both cotton." This factory was built of brick, and was continued in operation to some extent for several years, being driven by horse-power. After this, factories were built in other parts of Massachusetts, and also in Connecticut, Rhode Island, New Jersey, and several other states.

The following table taken from the report of Tench Coxe, of the census of 1810, shows the number of cotton factories in the different states at that time:

New Hampshire,	Twelve.	New Jersey,	Four.
Massachusetts,	Fifty-four.	Pennsylvania,	Sixty-four.
Vermont,	One.	Delaware,	Three.
Rhode Island,	Twenty-eight.	Maryland,	Eleven.
Connecticut,	Fourteen.	Ohio,	Two.
New York,	Twenty-six.	Kentucky,	Fifteen.
		Tennessee,	Four.

None in any other state.

But after the cotton manufacture was once started in this country, it progressed very rapidly, as is fully seen in the case of Massachusetts, upon examining the history of some of our most important manufacturing cities. The first mill was built at Fall River, in 1813, and in 1873, there were about thirty-three incorporated companies, owning 1,209,644 spindles. The Merrimac Mill, the first one built in Lowell, was erected in 1822. The Hamilton Mill was built in 1825, and afterwards the Appleton, Tremont and Suffolk, Boott, and several others were erected. In Lawrence, the increase in population, owing mainly to the rapid growth of cotton factories, was so great that it became a town in 1847, and in 1853, only six years afterwards, it became a city.

The number of spindles in New England in 1850 was estimated at 2,751,078; the population according to a census taken at that time being 2,728,106, which gives an average of 1008 spindles to 1000 inhabitants. Curiously enough, at this time in England, Scotland, and Wales, the number of spindles was 1003 for each 1000 inhabitants.

Having now given a hasty review of the early history and progress of the cotton manufacture, I will endeavor to give a general description of the various processes through which the cotton has to pass. I will begin with the cotton as it is brought to the factory in bales, having been previously ginned on the plantations where it was raised.

In order to make the cotton up into compact bales convenient for exportation, it is necessary to compress it in powerful presses, and this operation of course makes the cotton stick together in lumps, therefore the first process is to break up these lumps, so as to reduce the cotton to the same state that it was in, before being baled. In order to accomplish this, the bales are taken to the picker room, where they are broken open, and if various kinds of cotton are intended to be used together, they are mixed here. The cotton is then put into a machine called an opener or beater, where the lumps are in a great degree opened, and considerable of the dirt beaten out. As the cotton issues from this machine, it is spread out in a sheet, about two or three feet wide and one or two inches thick, and is rolled up on a wooden bar. Two or three of these rolls are then passed through another machine called a picker or lapping machine, which is furnished with blunt revolving knives, which tear the fibers apart, and thus complete the operation of opening the cotton. The cotton also comes from this machine in the shape of a roll, called a "lap," the weight of which varies with the size of the yarn which it is desired to make. Having now opened the cotton, the next operation is to straighten the fibers and make them parallel. In order to do this the "lap" is placed on a carding machine, which, in the form most commonly used in this country, consists of a large cylinder covered with leather, in which are set short, bent, sharp-pointed wires. Over the top of this cylinder are flat strips of wood, also covered with wire. In front of this large revolving cylinder is a smaller one, called a "doffer," turning in an opposite direction. The cotton is drawn through between the cylinder and the flat strips, and then passes on to the "doffer," from which it is removed by means of a fine comb, which takes off the cotton in a delicate lace-like sheet, but it is immediately passed through a trumpet-shaped opening, which condenses it into a narrow band called a "sliver." The "slivers" from five or six cards are then passed through what is called a railway head, which consists essentially of three sets of rolls, of two in each set, placed above one another. The back set, which receives the cotton, revolves a good deal slower than the front one, which delivers it, and thus the separate "slivers" are joined together and drawn out, which operation tends to straighten the fibers. As it is necessary that the weight of the sliver as it comes from the railway head, should be as uniform as possible, there is a regulator attached,

through which the sliver passes and the friction of the cotton causes the regulator to move forward or back, as the weight of the cotton becomes greater or less, and this movement of the regulator determines the relative speed of the rolls. From the railway head, the "sliver" is passed through two drawing frames, which are essentially the same as the railway head, except in a few matters of detail.

In both of these drawing frames, several "slivers" are passed in together and drawn out as one, the object of this "doubling" being that the inequality of one "sliver" may neutralize that of another. After the drawing on the drawing frames is completed, the "sliver" is too weak and small to stand any more drawing, and yet it is still too large for the desired yarn, and the fibers are not yet sufficiently straightened; it is therefore necessary to twist it slightly in order that it may bear more drawing. For this purpose it is passed through three machines, called respectively the coarse speeder or slubber, intermediate, and fine speeder or fly frame. These are almost precisely alike, and therefore a description of one will do for all. The sliver, which is brought from the machine last described coiled up in cans, is first passed through rolls, similar to those of the drawing frame, which are placed on the upper part of the frame, and from these rolls it passes down through what is called a flyer, *f*, (see Plate I, Fig. 2), and is then wound upon the bobbin, *s*. The drawn sliver enters through a hole in the top of the flyer centrally, passes over or along the bow to one leg, and down the leg to the point *f*, where it emerges and is led over to the bobbin. Both the flyer and bobbin rotate rapidly, and it is evident that the motion of the former causes a twist to be put into the sliver, or "roving," as it is now called. Now, if the roving passes through the flyer and is attached to the bobbin, and the latter moves faster than the former, it is evident that the yarn will be wound on the bobbin. As far as the winding on is concerned, it makes no difference which moves the faster; but some manufacturers prefer to have it one way, some another. The roving, having now passed through the three fly frames, is ready for the spinning machine.

Of spinning machines there are three kinds, *i.e.*, the throstle, ring frame, and mule. Of these, the former has almost wholly gone out of use in this country, having been superseded by the ring frame, although it is still used quite extensively in England. The ring frame, of

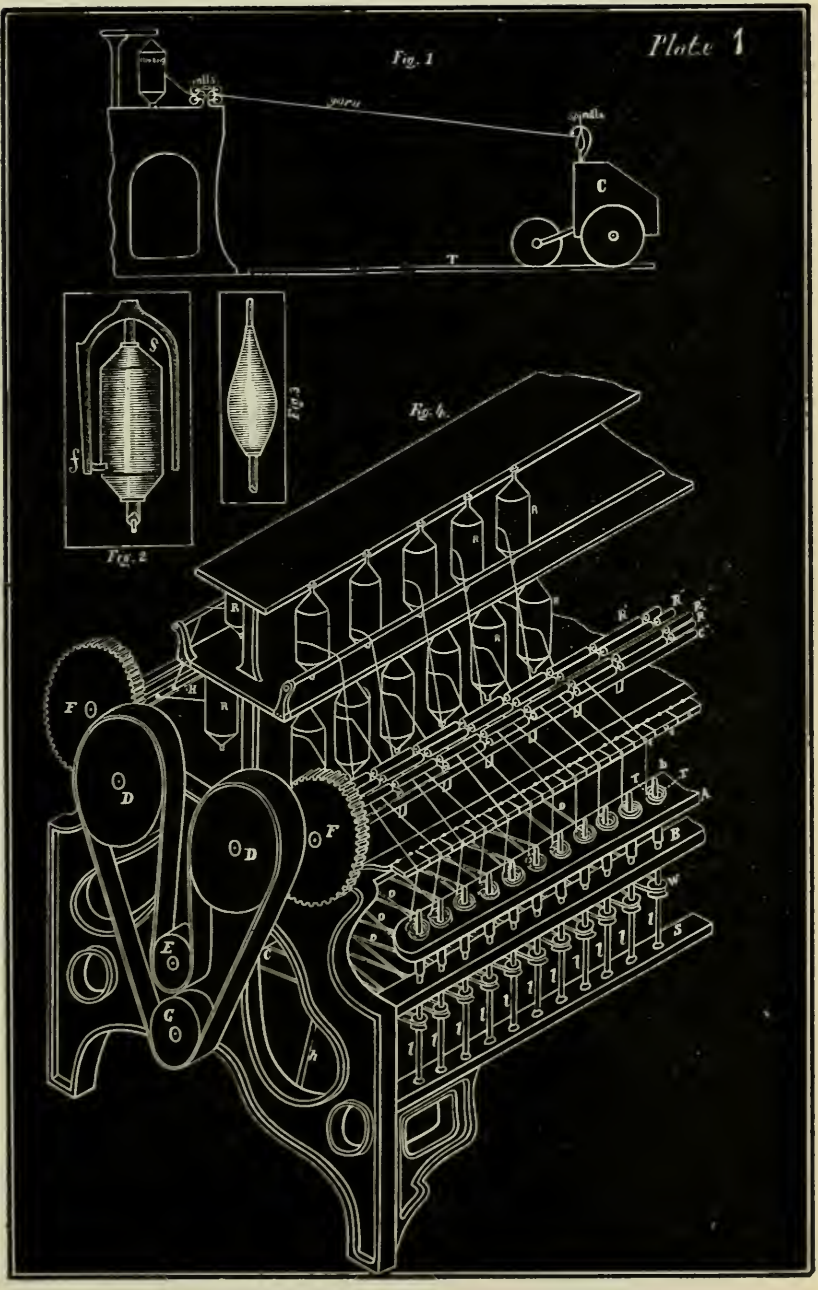
Plate 1
Fig. 1
yarn
spindle
C
T
S
f
Fig. 2
Fig. 3
Fig. 4.
R
F
D
E
G
H
A
B
W
S
T
h

which I shall have more to say further on, is used mostly for spinning the warp; and the mule for making the filling, and for very fine yarns. Fig. 1, Plate I, gives a general idea of the principle of the mule, although all the details and driving machinery have been omitted. The spindles, on which the yarn is to be wound, are placed in the carriage, *C*, which can be moved back and forth on the track, *T*. When the machine is started, the roving is passed through the rolls and attached to the spindles, which are then up near the rolls.

The axes of the spindles at this time are tilted over with the top ends towards the rolls, in such a way that as the spindles revolve, the twisted rovings, now threads, will pass over the end of the spindles, while, with the spindles in motion, the carriage *C* travels backwards on the track *T*, until it reaches the position shown on the drawing. After the elongated threads have been twisted for a short time with the carriage at rest, the rolls having stopped, the axes of the spindles are made upright simultaneously with a return movement of the carriage and a continued stoppage of movement of the rolls, and the threads are wound up on the bobbins when the carriage reaches its original place; and this operation is repeated until the bobbins or "cops" are full. Plate I, Fig. 3, shows the usual shape of the mule cop and the difference between that and the flyer bobbin.

The mule yarn is now ready to be used for filling, but in order to fit either it, or the throstle, or the ring yarn for use as warp, several more operations have to be gone through. In the first place, the bobbins are put on a machine called a spooler, which winds the yarn from the bobbins on to the spools, which are perhaps six or eight inches high. These spools are then set in a triangular frame, called a warper, and the yarn is then wound off on to what is called a beam, which is a sort of gigantic spool, being about a yard long—although its length varies with the required width of the cloth. The next operation is to size the yarn, in order to give it more firmness, so that it may not be injured in the process of weaving. In order to accomplish this, the yarn is passed through a tank containing the starch, and then between brushes and rollers, which remove the superfluous starch; and then the yarn is passed over hot steam-pipes to dry it; and eventually wound upon another beam, similar to the one mentioned before. In the most modern machine for dressing the yarn, called a slasher, the yarn is passed over a revolving cylinder heated by steam in order to dry it; and the whole machine

is more compact and does its work quicker than the old-fashioned dresser; for the finer yarns, however, such as Nos. 80 and 100, the old machine is found to do the best work. The ends of the warp are now passed through the eyes in the "heddles," or "harnesses," and the beam is then ready to be put on the loom.

The loom for ordinary weaving, has two harnesses which are moved alternately up and down. These harnesses, as they are called, each consist of two horizontal wooden bars placed directly above each other, and connected together by means of cords, having loops in the centre of each. In threading these harnesses, one thread is passed through the loop of one harness, one through that of the other, thus alternating with every other thread except on the edges, where two or three threads are passed through one loop, in order to form the selvedge. Now as these harnesses are moved up and down, an opening is left, through which the shuttle containing the bobbin of filling, is thrown by means of a sort of hammer, one of which is placed at each side of the machine, so as to drive the shuttle back and forth. Thus it is evident that the shuttle will go over every other thread, and on returning will go under the threads it went over before, thus forming good firm cloth. It is a somewhat curious fact, that although in order to have the drawing and spinning go on properly, it is necessary to have the air in the room quite dry, yet for good weaving, the air should be quite moist, and this is one of the reasons why it is advisable to have the looms on the lower floor. After the cloth has been woven, it is only necessary to examine it, to discover any imperfections, and it is then ready to be measured and cut to the proper length, and packed for exportation.

It must not be supposed from the hurried manner in which I have described the process of manufacture, and the various machines employed, that the operation is a very simple one, for on the contrary the whole process is one which requires a great deal of care, judgment, and experience, in order to be conducted successfully; and nearly all the machinery employed is quite complicated, some of it making use of a great variety of mechanical movements, which it would be impossible to describe here.

Having now briefly described the general process, I will take up more minutely the special method of ring spinning, and endeavor to point out some of its advantages and disadvantages, together with some of its peculiarities.

The invention of the method of spinning yarn by means of the ring frame, is undoubtedly due to John Thorp, of Providence, (although in some books it is attributed to John Sharp, of the same place; which however arose probably from careless writing); and in others to Mr. Jenks, of Pawtucket. In the Patent Office Reports, several patents are recorded as having been taken out by Mr. Thorp in 1829, in connection with cotton spinning machinery. In 1830 Mr. Thorp had one of his frames on exhibition in New York. It was somewhat similar to the frames now in use, in its general appearance, but was finished with only six spindles. It was driven by hand-power, and seemed to spin very nicely; the ring was quite different from those now in use, being furnished with a deep groove inside, into which a wire, bent to fit the ring, was set so that it could travel round in the groove. This inner ring of wire was furnished with a projection, to which the thread was attached. Mr. Thorp afterwards built some larger frames on this system, which however were not very successful. In 1833, Mr. Asel Lamphere, of Killingly, Connecticut, attempted to introduce the ring system of spinning into the various mills, and fitted over the old throstle frames; but unfortunately, almost all his attempts were failures, so that most of the manufacturers became very much prejudiced against the new system. In 1836, Mr. WILLIAM MASON turned his attention to the subject, (in which, in fact, he had always been interested since its invention by Mr. Thorp), and being a very skillful mechanic, he finally succeeded in producing a ring frame which worked well, so that to him is really due the credit of being the first one to make the ring system of spinning a success; he also introduced the modern style of ring and traveler. Since that time, the ring frame has undergone scarcely any radical changes, although each maker has his own method of carrying out the details.

The general arrangement of the ring frame is shown in Plate I, Fig. 4, drawn from a frame, made by the Saco Water-Power Company, (although several of the details, especially the mechanism for lifting the ring rail, are omitted). The roving passes from the bobbins R, (which are so placed as to revolve freely, as the roving is unwound) through the three sets of rolls, R' R'' R''', and thence through the thread guide t, and traveler T, to the bobbin b.

The method of driving the frame is as follows: In the lower part of the frame, and running the whole length of it, is a tin cylinder,

of which a very slight portion is shown at C in the drawing. This cylinder has a pulley at both ends; that at the farther end being driven by a belt from the shafting overhead, while the other one shown at E, drives the rolls. The cylinder itself drives the spindles by means of the bands or cords o o o. The twist pulleys D D, are driven from the pulley E by means of the band, as shown, G being only an idler pulley. The rolls and spindles are arranged in precisely the same manner on both sides of the frame, so that the same description will apply to both. In some frames, as for example, those built by the Lowell Machine Shop, the rolls are driven directly by gears from the cylinder, instead of by bands, as here shown. On the shaft with D, there is a small pinion called the twist gear, which drives the gear F on the front roll; on the same shaft as the gear F, there is a small pinion D, (see Plate II, Figs. 8, 9, 10, which show respectively an end elevation, plan, and front elevation of the rolls), which drives the stud gear B, which, as its name implies, is placed on a stud which is bolted to the frame. Connected with the stud gear, is the pinion gear C, which drives the back roll gear A. Thus it is evident that by changing the number of teeth in the pinion gear, any desired change in the relative speed of the front and back rolls can be made. The stud is, as I have before mentioned, secured to the frame by means of a nut, so that the necessary changes in its position can be easily made when the size of the pinion gear is altered. The middle roll is driven from the front roll by means of gears placed at the farther end of the frame; there is also an arrangement for adjusting the distances between the rolls, which is evidently necessary; for, if the front roll had a velocity equal to twice that of the middle roll, and the fiber was long enough to have the ends held by the two rolls at the same time, it would immediately be broken in two. The rolls must therefore be so adjusted, as to be just a trifle farther apart than the length of the fiber to be used. The rolls, as it has already been stated, consist of three sets, of two in each set; the upper ones, shown at H G E, Plate II, Fig. 9, and at I I' I'', Fig. 8, are made of iron covered with leather, and are held against the lower set by means of weights, so that the pressure on the roving and tension on the yarn is uniform, and may be adjusted for any pressure desired. The lower rolls, shown at J, Fig. 10, and J J' J'', Fig. 8, are made of steel and are fluted, so as to take a better hold of the roving, and feed it along with more certainty and uniform-

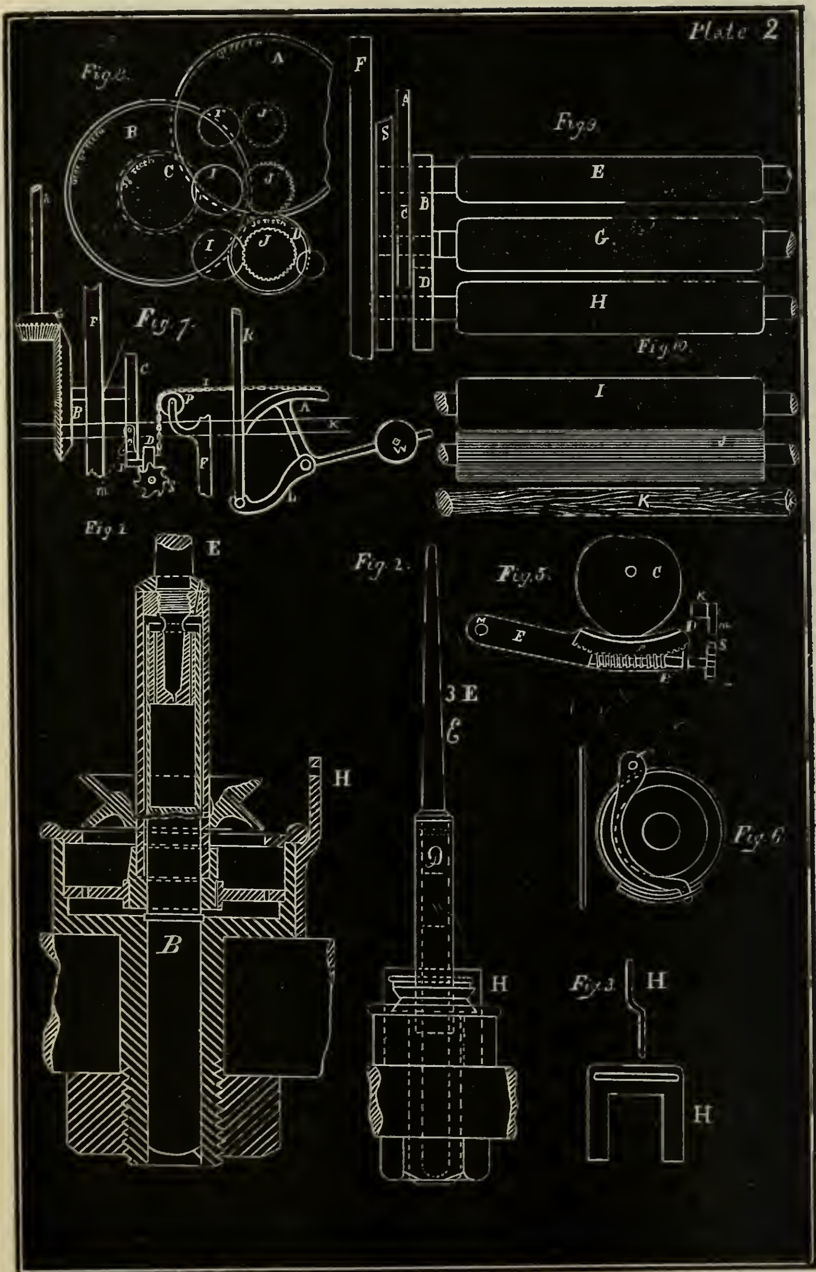
Plate 2
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 7.
Fig. 1.
Fig. 2.
Fig. 5.
Fig. 6.
Fig. 3.

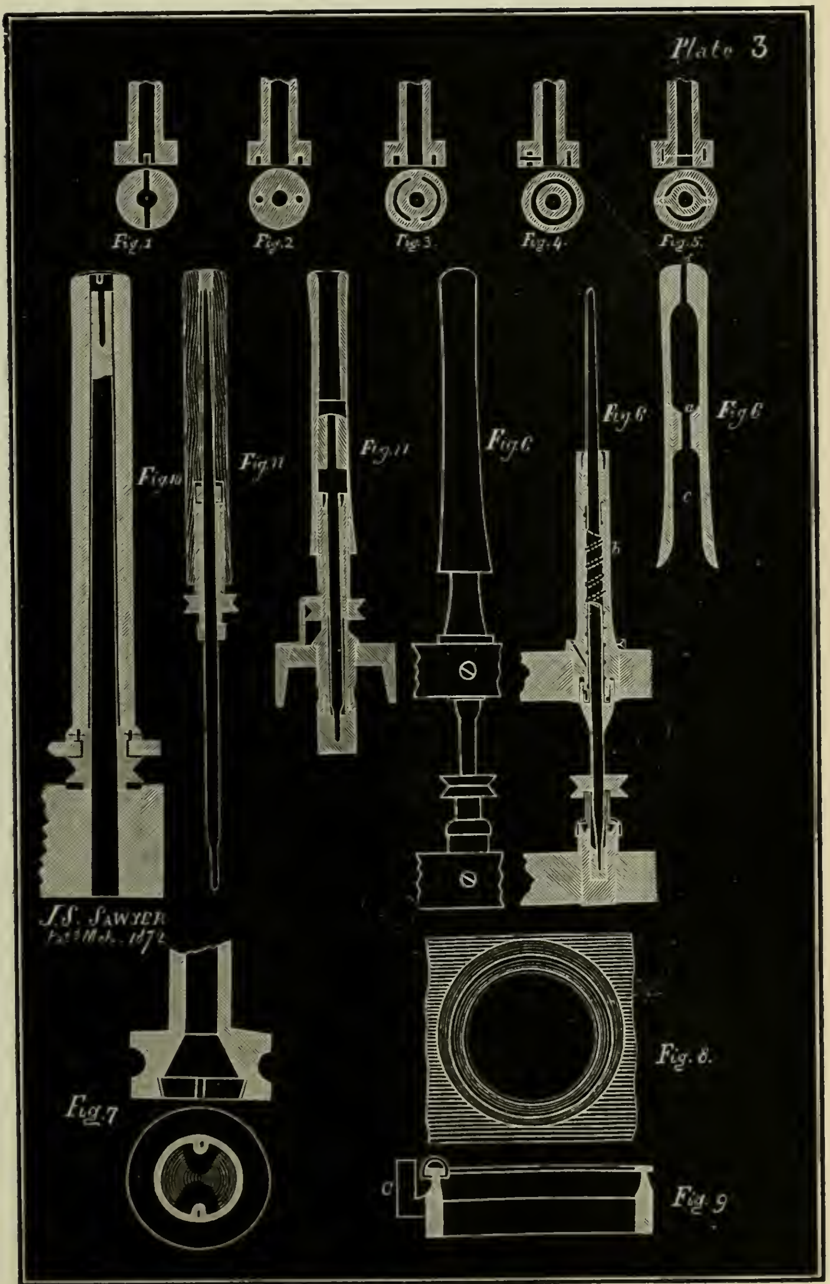

Plate 3
Fig. 1
Fig. 2
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 10
Fig. 11
Fig. 11
Fig. 6
Fig. 6
Fig. 6
a
c
b
J.S. Sawyer
Pat. Mch. 1872
Fig. 7
Fig. 8.
Fig. 9
c

ity. The roll K, Fig. 10, shown also at C', Plate I, Fig. 4, is made of wood, and is placed under the front roll, in order that, if the yarn becomes broken, it may lap around it, instead of lapping around the fluted roll. If the roving were allowed to pass through the rolls in exactly the same place, it would wear the fluting quite quickly; therefore there is a strip of wood placed behind the rolls, and parallel with them, which has a slow longitudinal motion back and forth. The roving is passed through holes in this piece of wood, (Plate I, Fig. 4, H) and this movement makes the rolls last much longer than they otherwise would.

The spindles are placed vertically, as shown in Plate I, Fig. 4, ll, and have two bearings; a lower one called a "step," which is sunk in the step rail S, and supports the weight of the spindle and bobbin, and another one called a "bolster," set in the bolster rail B. Both of these bearings are made in such a manner, that they can be easily oiled, and are covered to protect them from dust and dirt. W is the whirl or grooved pulley, by which the spindle is driven by the band o, from the cylinder C. Sometimes instead of driving each spindle with a separate band, as shown, two or three are banded together, and some tests made on frames banded in this way, show considerale reduction in the power required to drive them. A is the ring rail or wave rail which supports the rings, a section of one of which is shown in Fig. 9, Plate III, and of which more will be said farther on. This ring rail has a slow motion up and down, so as to wind the yarn uniformly on the bobbin. This "traverse" is usually about 5 or 5½ inches when it has its greatest value; now, if the yarn was wound up to the same point on the bobbin for every layer, it would most probably slip off, and get snarled up, and thus give a great deal of trouble; therefore both ends of the bobbin are made to have a conical shape, like the bobbins of roving, and, in order to do this, the traverse motion is so arranged that it becomes shorter as the bobbins grow fuller. Figs. 5 and 7, Plate III, show the mechanism for lifting the ring rail; Fig. 5 being the end elevation, and Fig. 7 the front elevation; the same letters referring to the same parts. h, shown also in Plate I, is a shaft which receives its motion from the front roll by means of a worm and wheel. This shaft, by means of the bevel wheel G, gives motion to the gear B, on the same shaft with which is the heart cam C, which presses against the pin p, and thus gives a swinging motion to the lever E, pivoted at M, to which the pin is attached. From this arm E, there is a chain I, which

passes over a pulley P, attached to the frame, and then is fastened to the arc A. On the same shaft to which the arc is fastened, is an arm to which a weight W is attached so as to keep the pin p constantly pressed against the cam. There is also another arm L, which supports the vertical rod R, which, passing up through the step and bolster rails, is attached to the ring rail, which it thus moves up and down. The ring rail, instead of extending the whole length of the frame, is divided in the middle, and each half has three lifting rods. Now, in order to cause the length of traverse to vary, the pin p is attached to a segment of a circle D, which has teeth on it fitting into a worm B', on one end of which there is a star wheel S, the teeth of which strike against a piece m (which hangs from the step rail); when the lever E is lifted by means of the cam, this, of course, causes it to turn slightly, which, by means of the worm and gear, moves the pin nearer the pivot M, and thus by reducing the leverage, causes a corresponding reduction in the length of traverse.

Some spinners think it best in building the bobbin, to begin with the longest traverse and gradually diminish it, while others begin with a short traverse and gradually lengthen it; but either of these methods can be used by a suitable arrangement of the worm. Some frames also are arranged so as to begin at the bottom of the bobbin with a very short traverse, and every time the ring rail comes down not quite so far as it did before, and runs up a little farther, so that the bobbin is built up in a succession of cones somewhat similar to a mule "cop."

Mr. Evan Leigh, in his book entitled "The Science of Modern Cotton Spinning," makes the following remarks in regard to the ring frame: "The principal difference between the ring and flyer frame consists in dispensing with the 'flyer' and substituting a 'ring' fastened in the lifting rail, which is made to traverse for the filling of the bobbin. The winding on or drag is got by means of a flat steel

wire, bent in a half circular form, with the ends turned in, as annexed, which is dragged round on the top flange of the ring by the yarn passing through it on the way to the bobbins. These steel wires are called travelers, and the counts of the yarn to be spun, and the speed of the spindles regulate the weight and size of them. Owing to the great speed of the travelers (each one going through space at the rate of about 30 miles per hour), they wear out in six or eight weeks, when they have to be renewed. Going at the speed of 6000 revolutions per minute, each traveler will produce about 100 miles of

32's twist on the average, before it is worn out, which is equal to about six pounds of yarn; therefore, a concern spinning 10,000 lbs. of yarn per week, would consume about eleven gross of travelers, which would be about the same expense as the washer cloth consumed by the flyer throstles for the same quantity of yarn. The rings are generally made of fine-grained Low Moor iron, carefully finished, hardened and polished. Their sizes also need to conform to the different weights of yarn; and the finer and softer this is required to be spun, the smaller must be the rings. The average size of them is $1\frac{5}{8}$ inches diameter inside (see Fig. 9, Plate III). It is necessary to oil the rings three or four times a day, to prevent rapid wear, and reduce friction. If proper care be taken by attending to their lubrication, the rings will last from six to ten years. The bobbins are always driven directly by the spindle, either by being pressed on to a taper blade, or by a bead or braid, with pins fastened to the spindles, and fitting into corresponding recesses in the bobbins. The form of bobbin, in the first case, is a plain tube called a quill, which is generally $6\frac{3}{4}$ inches long, but varies with the length of the traverse. The size at the bottom is $\frac{7}{8}$ inch in diameter, and the size at the top 13-16 inch, the centre part where the yarn is wound being turned slightly hollow for holding it firmer. The tops of the bobbins are well rounded off. The holes in the bottom of the bobbins are $\frac{3}{8}$ inch in diameter, and near the top $\frac{1}{8}$ inch. (These dimensions are for the common spindle). The traverse is generally about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches shorter than the length of the bobbins. There is a lengthening taper motion provided to secure the end layers, and prevent them from falling off. This kind of spinning frame runs very steady, owing to the well-balanced bobbin. The usual speed is 6000 to 8000 revolutions per minute of spindles for spinning No. 30's warp.* Still, there is an objection in piecing up, and in doffing, because the bobbins stick so fast on the spindles, that when required to be taken off, much time is lost in loosening them, thereby endangering the straining of the spindles, and the pushing off the yarn from the bobbins. Another form of bobbin is the straight tube, with bottom flange fitting loosely on the spindle, and being driven by the braids with pins."

(To be continued.)

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* This estimate of speed appears rather high, and from 5000 to 7000 revolutions per minute would probably be nearer the truth.

REPORT OF THE TRIAL OF THE STEAM MACHINERY OF THE UNITED STATES REVENUE STEAMER "GALLATIN,"

AT THE UNITED STATES NAVY YARD, BOSTON, MASS., IN THE MONTHS OF DECEMBER AND JANUARY, 1874–'75.*

By CHAS. H. LORING, Chief Eng'r, U. S. N., and CHAS. E. EMERY, Consulting Engineer.

[*Embodying a summary of the general results of experiments with the steam machinery of U. S. Revenue Steamers Rush, Dexter, Dallas and Gallatin.*]

The trial of the U. S. revenue steamers *Rush*, *Dexter* and *Dallas*, in the month of August, 1874—reports of which were transmitted to the U. S. Navy and Treasury Departments and shortly after widely circulated—furnished much valuable information as to the relative cost of the power in compound and non-compound engines, operated with the same and different steam-pressures at various degrees of expansion; but the comparison could not, with these vessels, be made in all respects complete for the reason that the cylinders of the compound engine were steam-jacketed, while those of the non-compound engines were not jacketed. At that time, however, new machinery was in process of construction for the U. S. revenue steamer *Gallatin*, of substantially the same power as that of each of the other vessels, the cylinder for which was steam-jacketed and the boiler designed to carry a high pressure of steam. Upon the completion of the *Gallatin*, it was arranged by the Navy and Treasury Departments to make a series of experiments with her machinery on the same system as the other vessels were tried, and under the general direction of the same persons, (the undersigned).

DESCRIPTION OF THE "GALLATIN."

The *Gallatin* is an iron screw steamer, with top-sail schooner rig, 147 feet long over all; 133 feet between perpendiculars at water-line, 23 feet beam, and 9 feet 6 inches depth of hold from top of cross floors to under side of main deck. The draught of water aft is about 9½ feet.

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* Communicated to this JOURNAL by Chas. E. Emery, C.E.—ED.

The vessel was modeled and constructed by Mr. David Bell, of Buffalo, New York, in the year 1870, and by direction of the Department was at first fitted with a steering propeller and machinery adapted for operating the same. The vessel was rebuilt by the same party in the year 1874, and provided with a screw-propeller and new steam machinery throughout, (except surface-condenser,) designed by Charles E. Emery, consulting engineer; some details of engine being adapted to the style of the builder so that the patterns would be of service to him for future use. With the new machinery the vessel, which has an excellent model, steams readily upward of eleven nautical miles per hour.

MACHINERY.

BOILER.

The vessel has one boiler of the ordinary American flue and return tubular, circular shell type, constructed of heavy iron, and strongly braced, of the following general dimensions and proportions:

Length of boiler, ...	15 feet 9 inches.
Width of front and diameter of circular shell, .	10 feet.
Height of boiler to top of circular shell, . .	10 feet 3 inches.
Diameter of steam chimney, ...	6 feet 6 inches.
Diameter of steam chimney-flue, . . .	3 feet 6 inches.
Height of steam chimney above shell of boiler,	7 feet.
Number of furnaces, ...	2.
Direct flues: two of 28 inches, two of 18 inches, two of 12 inches diameter; all 3 feet 7 inches long.	
Return tubes 124 in number, each 3½ inches in diameter and 10 feet 9 inches long.	
Length of back connection, ...	2 feet.
Length of front connection, ...	2 feet 6 inches.
Grate surface, ...	55·25 sq. ft.
Cross area of tubes for draft, ...	7·20 sq. ft.
Water-heating surface, ...	1805·163 sq. ft.
Steam-heating surface, ...	105·311 sq. ft.
Ratio cross area tubes to grate surface, . .	7·68
Ratio grate to heating surface, . . .	32·6
Ratio cross area tubes to heating surface, . .	250·98
Ratio cross area tubes to steam space, (9 inches above tubes), ...	52·2

ENGINE.

There is one main engine, of the inverted type, with steam-jacketed cylinder, 34·1 inches in diameter, with 30 inches stroke of piston. The comparatively short stroke was necessarily adopted in the design

to bring the main cylinder under the hurricane deck. Steam is distributed by a short slide-valve, arranged to cut off by lap at two-thirds of the stroke, and provided with adjustable cut-off plates sliding on its back. The air-pump is operated through levers from the main cross-head. Tho surface-condenser case does not form part of the engine frame, but is set on a separate foundation near the side of the vessel, and connected to air-pump by a pipe. The circulating pump is of the centrifugal type, of sufficient size to supply the necessary quantity of water at all times, with a speed of less than 200 revolutions per minute. It is operated by a vertical engine, with cylinder 4 inches in diameter and 6 inches stroke, directly connected to pump-shaft. The screw-propeller is 8 feet 9 inches in diameter, and has a mean pitch of 15 feet. The following are the principal dimensions of the engine:

Diameter of cylinder, ...	34·1 inches.
Stroke of piston, ...	30 inches.
Diameter of piston-rod, ...	$4\frac{3}{4}$ inches.
Size of cylinder ports, ...	$2\frac{1}{8}$ by 27 inches.
Ratio of piston displacement to capacity of clearances and passages, ...	·0659

The boiler, steam-pipes, and cylinder are thoroughly covered with hair felt and canvas, and exposed parts in engine-room have an additional covering of either Russia iron or black walnut, secured by brass bands.

Steam for jackets is ordinarily conducted through a felted pipe from bottom of steam-chest to upper part of cavity in cylinder-cover. A second pipe leads from the bottom of the cavity in cover, upward and around to the side-jacket, which is in common with the jacket for bottom of cylinder. By this arrangement any water which collects in bottom of main chest or cylinder-cover is carried into the main jacket, from which all water is blown into hot-well through an intermediate vessel provided with a glass gauge. A small throttle-valve on the discharge-pipe from the vessel is regulated to show a water-level in the glass at all times, thus preventing loss of steam or an undue collection of water.

The boiler was designed to carry regularly a steam-pressure of 60 pounds. At the time of the trial it was nearly new and was worked part of the time with a steam pressure of 70 pounds, to correspond with that carried during the trials of the revenue steamers *Rush* and *Dexter*, previously mentioned.

MANNER OF CONDUCTING THE EXPERIMENTS.

The experiments with the *Gallatin* were made under the general direction of the undersigned, at the U. S. Navy Yard, Boston, Mass., in the months of December, 1874, and January, 1875, and the system adopted was similar to that used during the trials of the U. S. revenue steamers *Rush*, *Dexter* and *Dallas*, made under the same general direction in the month of August, 1874, full particulars of which may be found in the report of same, dated October, 1874. The following officers were detailed by the Navy and Treasury Departments, respectively, to take immediate charge of the experiments, viz: Chief Engineers Charles E. De Valin and Edward Farmer, U. S. Navy; Chief Engineers Chas. A. Satterlee and Chas. H. Ball, U. S. Revenue Marine; Passed Assistant Engineer W. D. Smith and Assistant Engineer J. A. Tobin, U. S. Navy; and First Assistant Engineers John T. Collins and J. A. Severns, U. S. Revenue Marine. Each chief engineer with an assistant stood regular watches while the experiments were in progress, and signed the original log. One of the undersigned was at all times on the vessel or within call. The computations were made by Passed Assistant Engineers Greenleaf and Brosnahan, and Assistant Engineer Gates, U. S. Navy, and Mr. E. Hugentobler in behalf of the U. S. Revenue Marine.

The experiments were made with the vessel secured to the wharf.

The coal, which was anthracite of fair quality, was broken on the wharf to proper size, (the vessel's bunkers having been closed and sealed) and filled into bags to a certain weight.

The bags were sent on board when ordered by the senior engineer on watch, he making record on the log of the number of bags and the time of receipt, a similar record being made by one of the men on the wharf. At the end of the hour the number of bags of coal actually put on the fire was reported from the fire-room and entered in the appropriate column. The several records agreed with each other, and the total amount expended corresponded with the total number of bags filled on the wharf. The ashes were measured into buckets, of which the mean weight was ascertained and tallied as they were hoisted out. They were afterward weighed in gross on the wharf and the two accounts found to agree substantially.

The feed-water was measured after its delivery from the surface-condenser, and before its return to the boiler, in the tank used during

the previous experiments, which was constructed of boiler-plate and was divided by a partition of same material into two equal parts. In the upper edge of the partition-plate was cut a rectangular notch, eight inches long, by which the height to which each half of the tank could be filled was determined. The mean of the weight of water which the half tanks contained was 1129½ pounds at a temperaturo of 72 degrees Fahrenheit. In the computation of each experiment the weight of water is reduced to correspond with mean temperature. The measuring tank was erected on the hurricane deck, just abaft engine room skylight, and covered by a temporary cabin, in which was a small stove with which the assistant could regulate the temperature of the inclosure at will. [The previous experiments were made in the summer, and the tank was sheltered from sun and rain simply by the deck-awning.]

One of the feed-pumps was disconnected from the check-feed valve and arranged to discharge the condensed water from hot-well into a small receiving-tank supported above the measuring tank. The receiving-tank had on its bottom two cocks, one over each half tank, so that either could be filled from it at will.

The other feed-pump had its suction-pipe detached from the hot-well and connected with the bottoms of the two half tanks through a cock on each, so that the contents of either could be drawn out and discharged into the boiler.

The method of measuring the water and recording it was as follows: One side having been filled, the cock over it on the receiving tank was closed, and the other over the empty half opened. When the water in the full one had settled to the height of the edge of the notch, its cock in the feed-pipe was opened and its contents pumped into the boiler, (care being taken to empty one in less time than it required to fill the other); when empty, its feed-cock was closed. When the water in the tank being filled reached within a few inches of the notch, a gong in the engine room was sounded to call attention; and when it reached the notch, the gong was struck twice; at this instant the assistant engineer in the engine room noted the reading of the counter, and an attendant in the fire room noted and reported the height of water in the glass gauge on the boiler, as shown by a scale of inches secured to it. The attendant at the tank also noted the time of filling and the temperature when the tank was half emptied. After entering the number of the counter in the log, the assistant en-

gineer ascertained the numerical difference between that and the preceding entry, and if it was far from the average, its cause was sought for.

By this system of checks all errors of record could be detected, and it was possible to preserve and utilize any continuous run which came to an end through derangement of the engine. All parts of the tanks, pipes, and cocks were plainly visible to the eye, and had any leaks occurred therein they must have been detected.

The water from steam-jacket, steam chest, etc., was measured as follows: The discharge pipe from the drip vessel, previously mentioned as connected with the lower part of steam-jacket, was led through the coil of an ordinary ships' distiller, the coil being kept cool by allowing circulating water from the condenser to flow through case surrounding same into the bilge. This formed a refrigerating apparatus, and the water from jacket, etc., being cooled thereby, was permitted to flow freely into an open tank set on a scale. When the tank was full the discharge from refrigerator was temporarily shut off, and the weight of tank and water noted. The tank was emptied by suction through a pipe dipping therein and connected with condenser. The suction-pipe was provided both with a stop and an air-valve, the latter being opened when tank was filling, to prevent any water being drawn into condenser at that time by leakage of the former. The water being delivered in condenser formed part of that received in hot-well, and was therefore charged in determining the cost of the power.

The surface-condenser, boiler, and steam and water connections proved quite tight, so that the water lost in the circulation to and from the engine was very slight, and only during the longer experiments was it found necessary to add water to maintain the average level in boiler. The small amount thus required was run from the hydrant into the tank which was at the time being filled, and was therefore measured and charged in the cost.

Indicator diagrams were taken every twenty minutes throughout the trials, and the data for the usual columns of the log immediately after filling a tank, or not less than three times an hour, in all cases. The indicator employed was one of those used during the trials of the other revenue steamers above mentioned, which again proved correct upon being tested.

The results of the experiments are shown in the first of the accompanying tables, lines 1 to 44 inclusive, containing the several

observed and computed quantities upon which the performances, set forth in the remaining lines, are based.

As indicated by the general headings, a series of experiments was made at the several approximate steam pressures of $12\frac{1}{2}$, 40 and 70 pounds, both with and without steam-jacket in use, and for the higher pressure with and without vacuum. In some cases also the steam was throttled, in others the link was hauled up and the steam cut off by the lap of the main valve. The effect of using steam in jacket of higher pressure than that in cylinder was also tried, and the effect of draining the main steam chest both with and without use of steam jacket.

To ascertain the evaporative efficiency of the boiler, the machinery was operated continuously for 48 hours with an approximate steam pressure of 70 pounds. During the first 24 hours of this period the steam-jacket was in use, and the run, for this time, is designated No. 38 in Table. For the last 24 hours the steam was shut off the jacket and the pipes disconnected; for this time the run is designated No. 33 in Table. The evaporation is calculated separately from each of these runs on the basis of the coal charged in log for the respective times, and it will be seen in line 55 that the results correspond closely; run No. 38 showing an evaporation from observed temperature and pressure of 7·34 pounds water, the rate of combustion per square foot of grate being 15·3 pounds per hour, while in run No. 33, with the increased rate of combustion of 16·3 pounds, the evaporation was 7·26 pounds of water. The two runs, 38 and 33 (though the records are arranged for classification under different heads) were actually consecutive, the latter being held to commence when steam-jacket was shut off, without any stoppage or other change of condition. The runs taken together can then, as respects evaporation, if desired, properly be calculated as one of 48 hours' duration.

In all cases, when steam was shut off jacket, a joint was broken in the jacket connections to let in air and prevent the possibility of any leakage being undetected.

For the remaining experiments, which were each but two hours long, approximately, the water measure was used to determine the cost of the power, as the coal could not be distributed accurately for such short intervals.

By adopting a duration of two hours for a majority of the experiments it became possible to obtain far more information in the limited

time than in any other manner, and it is believed that the result can be depended upon fully as well as if the experiments were each of 48 to 96 hours' duration and fewer in number. In determining the variation due to changes of condition, it is important that all conditions remain uniform during each experiment, which is practicable for short but not for long runs. It may be claimed that a mistake in an observation will affect a long run less than a short one, but the fact seems to be that any important error will, for a short run, give such a wide difference of result, compared with other runs, as to indicate the probability of a mistake at once. We acknowledge that a single short run may be of little value; but by making a series of such runs, in which but one condition is changed slightly for each experiment, the results of the several experiments may be compared together, (by plotting the same in a curve, for instance), when a general correspondence will usually be observed, which will enable errors in observation or calculation to be detected, and insure a degree of accuracy generally impracticable for a long run, where an error affects the final result only and may never be discovered. It will often occur, however, that the average cost of the power will be less for short runs than for long ones; the short runs giving the accurate maximum results due to uniform conditions, which form the true basis for scientific comparison, while for long runs the results, at the best, can only be averages of maximum and inferior results. The maximum can be obtained permanently by keeping the conditions uniform —for instance, the economy due to a high steam pressure is obtained on land by using large boilers and automatic regulating devices. The short runs may then, in general, be considered as showing what is *possible* with *proper* apparatus; the long ones what is *possible* continuously with the *particular* apparatus tested.

In working out the experiments a number were found not to correspond with others of the same series, and in a few of them, errors of observation or faults with the indicator diagrams were discovered which necessitated their rejection. Those in which no errors could be detected have been retained, as we have not felt authorized to reject any without cause, though most of the discrepant ones were made during the first few days, before the entire force had become thoroughly acquainted with the duties. In two experiments, Nos. 10 and 12, the atmospheric line was misplaced on the diagrams, but, the latter being otherwise perfect, the misplacement was corrected by com-

parison with other diagrams. The most important difficulty with the diagrams was, however, caused by the sticking of the indicator-piston from the action of the lubricants in main cylinder. The difficulty was known and provided for by regular periods of cleaning indicator, but it appears that the precaution was neglected occasionally, particularly by one assistant, till the distortion of diagrams could be seen by the eye without using the scale. The experiments with faulty diagrams were rejected, except seven of the short ones, in which the action had only progressed sufficiently to change the position of the vacuum line. These experiments, which are numbered, respectively, 13, 30, 34, 37, 40, 41, and 42, and distinguished by an asterisk in Tables, have been carefully corrected by comparing the diagrams and the records of vacuum thereon with others taken under similar conditions.

We feel assured that many of the contradictory results of experiments heretofore published have been due to mistakes in observation or faults in the working of instruments, which were either undiscovered or neglected, and have therefore felt it our duty to state fully what occurred during these experiments, notwithstanding the interest manifested by the officers engaged, the system of checks and counter-checks, and in general, the extraordinary care taken to insure accuracy.

It is evident, however, that the character of the results is sufficiently indicated by the thirty-six experiments, about which there is no question. The seven others referred to have been corrected, we think, on an accurate basis, and retained for what they are worth, simply to preserve the symmetry of the series of runs.

To determine what may be called the quality of the steam—in other words to ascertain whether it was moist, saturated, or superheated, and in what degree moist or superheated—a calorimeter was erected in the gangway abreast of engine room, consisting of a large tight barrel set on a platform scale, with a screw propeller mounted inside and near the bottom of the barrel on a vertical shaft, terminating at the top with a crank. In the barrel was hung a large thermometer. To the bottom of the throttle-valve chest, on side of main steam chest of engine, a connection one inch in diameter was made, the pipe running up inside to the height of one of the ports admitting steam to main chest, which pipe connected through a valve to a short piece of hose, which was warmed by blowing steam through the same

just previous to an experiment. The barrel being filled with water, its weight and temperature were accurately ascertained, and the hose, with steam at the time escaping therefrom, quickly thrust in the water, the steam turned on more fully, and the propeller revolved. With the latter a decided circulation could be easily obtained, which immediately equalized the temperature. When the temperature had risen to the degree desired, the steam was partially shut off, the hose removed, and a final observation of weight and temperature immediately taken.

Table showing results of Experiments with Calorimeter.

1	2	3	4	5	6	7	8		9
Designation of Experiments.	Steam pressure in boiler above atmosphere.	Original weight of water in Calorimeter.	Weight of steam and water added to Calorimeter.	Temperatures.			Percentage of moisture in steam.		Number of degrees superheated.
				Initial.	Final.	Range.			
	Lbs.	*Lbs.*	*Lbs.*	*Deg.*	*Deg.*	*Deg.*		*Averages.*	
1	67·6	345·750	21·00	38·50	106·50	68·00	—1·96	1·58	....
2	70·1	334·625	20·50	49·00	113·50	64·50	4·80		
3	64·1	352·875	22·75	39·75	110·40	70·65	·05		
4	68·5	354·625	23·50	39·25	111·12	71·87	1·44		
5	60·5	339·000	22·50	34·50	105·50	71·00	3·60		
6	11·8	357·500	13·00	61·12	101·40	40·28	—2·34	—2·34	46·0
7	43·8	355·500	20·25	39·50	102·75	63·25	—1·37	—1·02	19·3
8	42·8	315·250	23·75	37·00	112·30	75·30	—0·67		

These experiments were made on different days with different steam pressures, and at different intervals in relation to the time when fires were cleaned. The results of the trial are shown in the foregoing table in connection with the data from which they were calculated. The steam pressures are those in the boiler, and as the steam pipe was large and short, it is believed that there was no considerable reduction of pressure in the throttle-valve chest. The metal propeller and shaft being immersed in the water were subject to the same changes of temperature, and for simplicity their influence on the result was estimated on the basis of their specific heats and ascertained

to be equal to that of one and one-half pounds of water, which quantity has been added in each case to the actual amount of water in calorimeter. The quantities in column 8, showing the percentage of moisture in the steam, are negative for experiments in which the steam was superheated, that form of expression being used for convenience in determining the averages for the several approximate pressures.

The second of the accompanying tables is a summary of the results of experiments made with the revenue steamers *Rush*, *Dexter*, and *Dallas*, referred to at the beginning of this report, and of the experiments with the *Gallatin*, hereinbefore set forth. The general arrangement of the table will be understood by inspecting the headings in connection with the descriptions of conditions, etc., written opposite the lines. The principal quantities influencing the results have been copied from the original detail tables, and others have been added, showing the weight of water required to be condensed per hour to supply the mechanical equivalent of heat for the total work, and the influence of same on the calculated cost of the power. The calculations are made for the total work done both before and after the point of cut-off, without discussing the correctness of the system, but simply to correspond with similar quantities heretofore published by others in connection with experiments of this character.

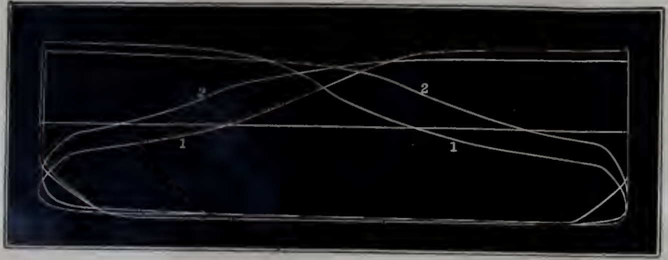
The actual weights of feed-water used per indicated horse-power per hour are shown in column 20, and may be used for comparing the cost of the power in the various engines under the several changes of condition. Since, however, the evaporation of the water during the experiments with the higher steam pressures required a little more heat than with the lower, there has been presented in column 23 a comparison of the cost in pounds of coal per indicated horse-power calculated from the cost in water per column 20, but allowing for the difference in pressure at which the evaporation took place; the uniform basis of calculation being that each pound of coal imparted to the water 9265·34 heat-units, which is equivalent to an evaporation of $8\frac{1}{2}$ pounds of water per pound of coal from a temperature of 120°, and at a pressure of 70 pounds above the atmosphere, a rate practicable in good marine boilers, and readily exceeded in land boilers. The quantities in line 23 show, then, the true relative cost of the power in fuel on a uniform basis; and for convenience, column 24 has been added, showing relative costs on same basis, with experiment

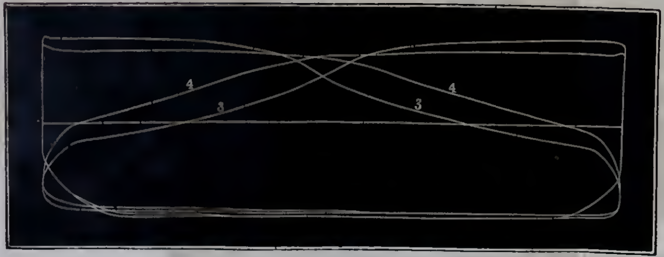
INDICATOR DIAGRAMS

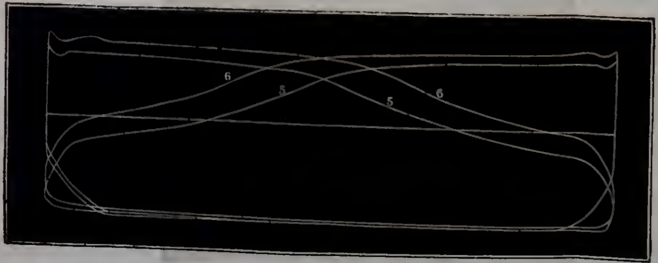
To accompany report of Experiments made with the Steam Machinery of the U. S. Revenue Steamer GALLATIN, under the general direction of Chief Engineer Chas. H. Loring, U. S. N., and Chas. E. Emery, Consulting Engineer, U. S. R. M.

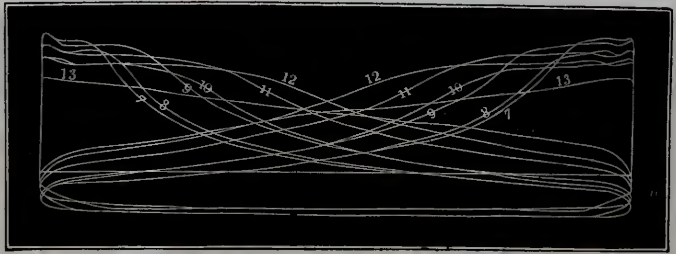
The numbers on diagrams refer to the numbers of experiments as written in first table, and in Series II of Summary.

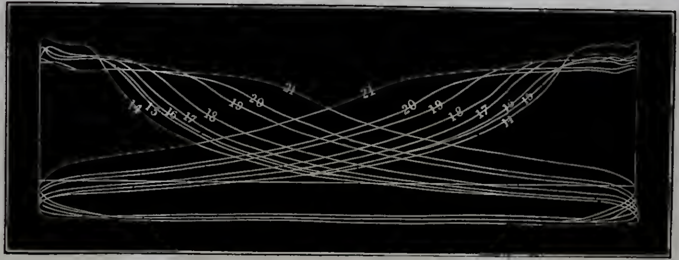
Scale of Indicator, 16 pounds per inch.

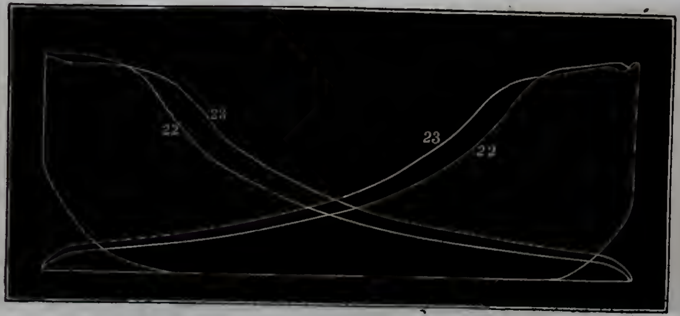


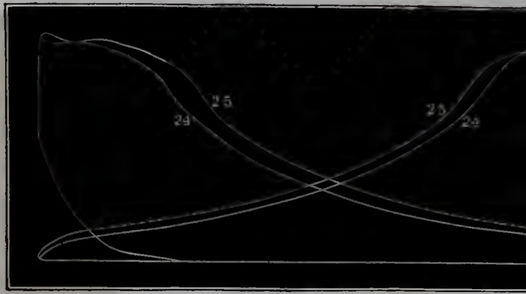


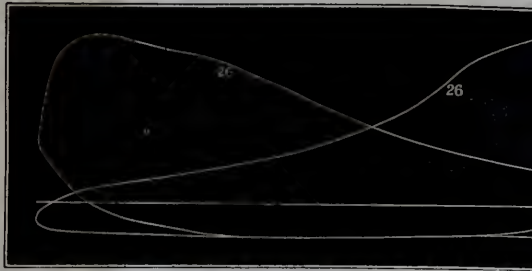


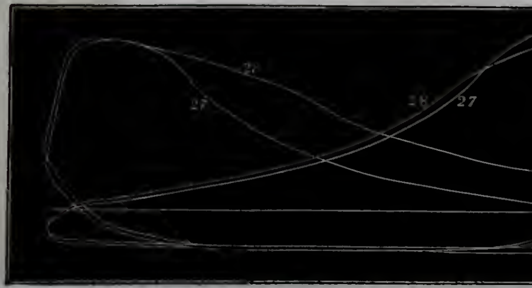




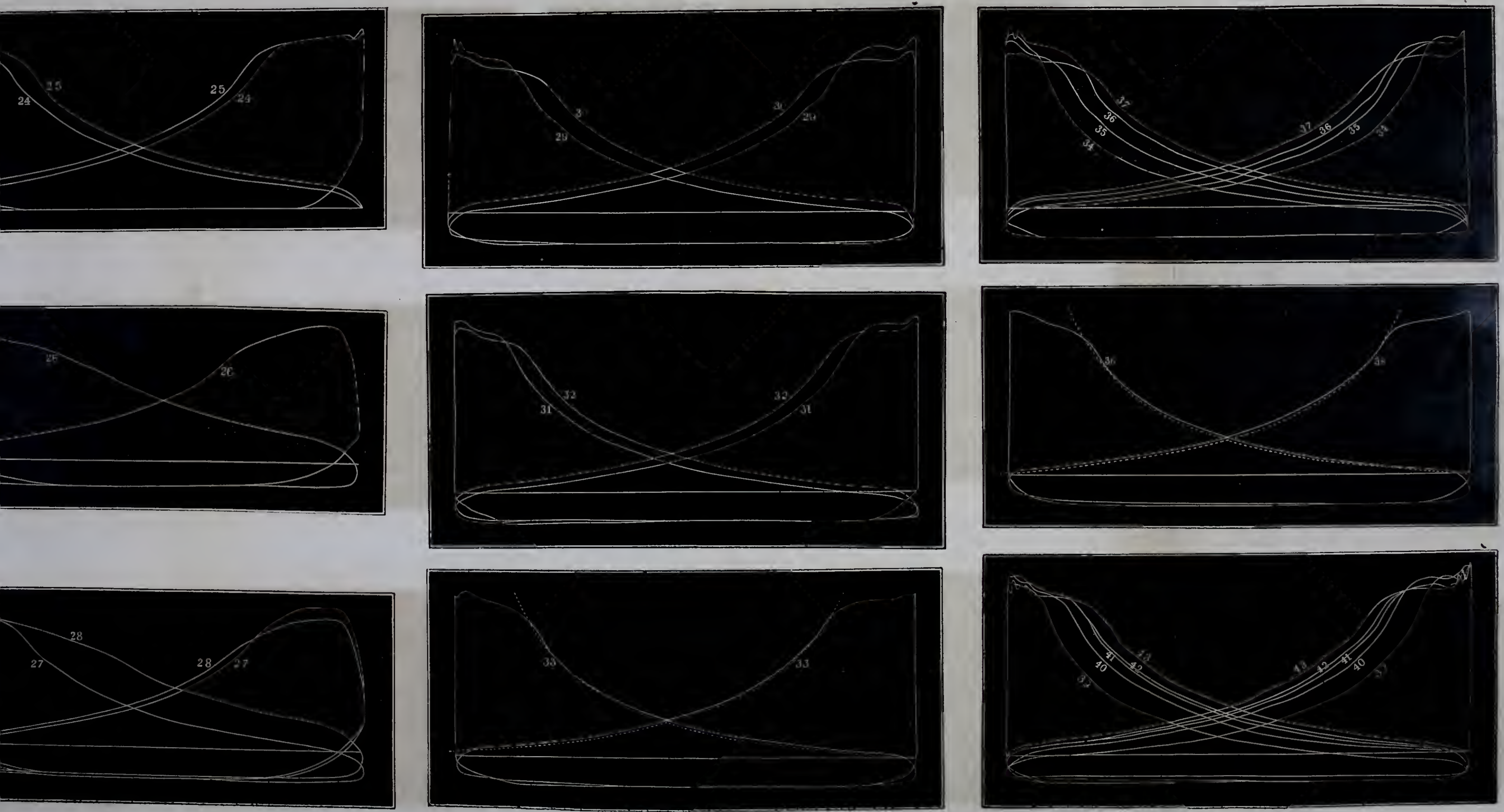








...GRAMS. SCALE OF INDICATOR, 40 POUNDS PER INCH.



No. 1 of first series as unity. No attempt has been made to present in the summary either the relative cost of the total or of the net horse-power. The former is unnecessary for ordinary investigations, and late experiments appear to indicate that in engines of substantially similar size, with similar valves and valve-gear, the net power is nearly proportioned to the indicated power. Both the total and the net powers, calculated by the ordinary methods, have, however, been presented in the detail tables, with the cost of each in feed-water. Annexed will be found specimens of indicator diagrams, taken during the several experiments.

C. H. LORING, *Chief Engineer, U. S. N.*
October, 1875. C. E. EMERY, *Consulting Eng'r, U. S. R. M.**

GAS WORKS ENGINEERING.

By Robert Briggs, Civil Engineer.

In a previous number of the Journal (that for October, 1875, vol. C. page 242), will be found a specification for a telescopic gas holder with crown top, which was prepared methodically so as to make a full specification in the briefest words. To complete the presentation of construction of gas holders, a similar specification is now offered for a single-lift gas holder with flat top.

Without entering into the discussion of the question of flat top holders (which the writer has been planning and building extensively since 1851), it will be simply stated that at 60 feet in diameter, and below, the advantages of durability, freedom from accident, light weight, and above all, prime cost, are so decided that no argument is necessary. Above 80 feet in diameter some considerations of construction so affect the cost, that the predispositions of superintendents of gas works may influence the engineer or contractor in favor of a crown top holder.

These flat top holders require no internal framing to carry the top when the holder is landed, and especially not a central pier support. If the top is permitted to hang by the curb freely, it can be relied

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* Note.—Indicator Diagrams taken during the trial of the Steamers "Rush," "Dexter," and "Dallas," may be found in vol. xcix, pages 201–5, (March, 1875).

upon to carry, not only its own weight, but also the weight of a foot of wet snow; 8 or 10 inches of water in the form of a plano-convex lens; 15 or 20 men; or any other load of necessary character, and yet not be strained by tension on the iron of the sheets, between the rivets, above the working tensile strength of 11,000 to 12,000 lbs. per square inch.* The only disturbance of the parts of such a holder when it lands, is the falling in of the top carriages at that time, so that the wheels leave the guides; but upon inflation of the holder this derangement adjusts itself, and the rollers find their place anew. This subject of the strength of the flat top crown may be reverted to at another time.

As the contents of an open top cylindrical vessel bear a maximum ratio to the surface of the sides and bottom, (the envelope being supposed to be of equal thickness throughout), when the sides are one fourth of the diameter; so there also exists a maximum ratio between the contents and the weight of the envelope of a gas holder; in which the crown has one thickness and the sides another, with curbs, legs and all considered; which ratio determines the proper height of the side of a gas holder as compared to its diameter. In the gas holder question, the tank and its cost, form a part of the problem, and the proportions should be fixed so as to give the largest contents for gas for the smallest expenditure on holder and tank together. It has been found that if the height of sides be taken to be $0{\cdot}28d + 3{\cdot}2$ that a scale of heights for given diameters ($= d$) will be found, which scale, a comparison of examples actually taken out, will be seen to nearly fulfill the conditions; as follows:

Diameters,	8,	10,	12,	14,	16,	20,	24,	28,	32,	36,	40,	45,	50,	60.
Heights,	5·44,	6·0,	6·56,	7·12,	7·68,	8·8,	9·92,	11·04,	12·16,	13·28,	14·40,	15·8,	17·2,	20·0.

It will be found practicable to bring the weight of the iron work of holders built to these proportions to $2\frac{1}{2}$ inches of water pressure, and when the thicknesses, etc., thus found, are examined, they will exhibit such dimensions as will satisfy the most critical in proportion of parts. The following specification shows the dimensions for a 60 ft. holder.

SPECIFICATION FOR A SINGLE-LIFT GAS HOLDER.

FLAT TOP CROWN.

For ____________________________

Working contents of holder 5654 cubic feet. (Allowing six inches submersion of sides when up.)

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* The assumed loads for top of holder have been taken as maximums of actual occurrence, by accident or otherwise.

This holder will have a weight of $2\frac{1}{4}$ inches water pressure.

CROWN.

Curb Sheets, { Width, 2 feet 0 inches.
Thickness,* No. 10.

Remaining sheets of crown, No. 12.

SHELL.

(Upper and Lower) Curb Sheets, { Width, 2 feet 0 inches.
Thickness, No. 13.

Intermediate sheets, thickness, No. 15.

Upper curb, angle iron, $4'' \times 4'' \times \frac{7}{16}''$.

Lower curb, angle iron, $3'' \times 3'' \times \frac{3}{8}''$.

12 legs, **T** shape to be built of 2 — $1\frac{1}{2}'' \times 1\frac{1}{2} \times \frac{3}{16}''$ **L** with a web of $5'' \times \frac{1}{4}''$ flat, and to have a backing plate of flat iron $3\frac{1}{4}'' \times \frac{1}{8}''$ on outside of section, countersunk riveted.

12† chord ties, $2'' \times 1\frac{1}{4}''$ flat iron, to lower curb, running from each leg to foot of second leg, and riveted to curb and at intersections.

The splices, gussets, thickening plates (where brackets are attached), etc., to be of suitable dimensions. Manhole on crown of holder.

6 carriages, with base plates and guide wheels on top of holder.

12 carriages, with rollers on lower curb.

Two coats of metallic paint to be applied, one before shipment and one after erection ; the latter coat on inside and outside of holder.

HOLDER FRAME.

6 cast iron columns, with base plates, placed at equal distances around circle formed by the tank, which shall be 62 feet 2 inches inside diameter.

The entablatures to be 1 foot 8 inches high, and securely clamped to capitals.

6 wrought iron lattice girders, 1 foot 8 inches high, connecting columns together at top, composed of two pieces of angle iron.

$2\frac{1}{4}$ inches $\times$ $2\frac{1}{4}$ inches $\times$ $\frac{5}{16}$ inch at top and bottom with flat iron, $1\frac{3}{8}$ inches $\times$ $\frac{1}{4}$ inch, crossed and riveted to angle iron, and at intersections.

Girders firmly bolted to entablatures.

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* Refers to Birmingham Wire Gauge.

† Chord ties are not requisite except in windy locations.

12 tank guides, of cast iron, with hoop iron anchor strips, to be built in brick work of tank.

Each column to have 2 foundation bolts, $1\frac{1}{4}$ inches diameter, and 6 feet 6 inches long, to be built in tank wall, and secured by cast iron washers, 12 inches $\times$ 12 inches $\times$ $1\frac{1}{4}$ inches thick in centre of washer.

Cast iron pipes, as per drawing, for 8 inch inlet and 10 inch outlet to tank of holder, with two drip boxes, 14 and 16 inches diameter $\times$ 27 and 36 inches deep, with hand pump for same.

Two coats of metallic paint to be applied on all exposed surfaces of the holder frame, one before shipment and the other after erection.

The whole of the work specified to be delivered at..

....

It is stipulated that the tank shall be kept dry by the gas company, and that lumber for scaffolding shall be provided by them. The erection of and removal of which shall be done by the builder, and the material shall be used without unnecessary waste, and, on completion of the holder, be carefully piled upon the adjacent ground.

All carpenter work, masonry, excavation, and the placing of inlet and outlet pipes, and setting of foundation bolts and washers, and of tank guides in wall of tank, shall be done by the gas company.

All material to be of the best quality, and the work done in first-class manner, subject to the inspection, and to be completed to the satisfaction of the engineer of the gas company.

Steel Rail Rolling in South Wales.—The two longest steel and iron rails ever rolled in South Wales were rolled in the Goatmill Right (Dowlais ironworks) a short time ago. One steel rail measured 105 ft. 2 in., and the other 107 ft. 9 in. The longest previous to these was rolled at the Ebbw Vale Works, and was 89 ft. only. Again, in the Bessemer department they turned out, (with one pit, two 5-ton converters—one cupola only working at the time), for the four weeks ending Saturday, December 21, no less than 460 casts; each cast containing 5 tons 16 cwt. of pig iron. This will give an average of 10·5 casts with one cupola per twelve hours, which is by far the greatest number upon record. It should be stated that on Saturday they only have five casts, so that the men may finish by noon.

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.†

[Continued from Vol. lxxi, page 67.]

It was subsequently, however, discovered‡ that at higher temperatures carbonic oxide is oxidized by watery vapor to carbonic acid, so that if the steam is in excess a gas may be obtained relatively free from carbonic oxide, as shown in the reaction—

$$C + {}_2H_2O = {}_4H + CO_2.$$

In the gas-water prepared at Narbonne, where the gas on issuing from the retorts is conducted through ignited tubes along with fresh quantities of superheated steam, Verver§ found in 1858, 3·54 per cent. of carbonic oxide. According to other observers the amount ranged from 2·5 to 5 per cent. In the water-gas at Passy, Payen found 6 per cent. of carbonic oxide, whilst in ordinary coal-gas he found an average of no less than 14 per cent. The above mentioned objection, therefore, no longer holds good.

The carbonic acid is removed by milk of lime, or, perhaps, more economically, according to the suggestion of Heurtebise|| by soda, which is thereby converted into bicarbonate, a readily saleable substance.

Fayes¶ constructed for lighting the town of Narbonne an apparatus which he named gazogen, which furnished in twenty-four hours 1000 to 1200 cubic meters of purified gas, the cost of which, inde-

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* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† From the *Chemical News*.

‡ Bromeis, *Zeitsch. d. Ver. deutsch. Ing.*, iii. 82, and *Dingler Polyt. J.*, clxiv. 33, 1895.

§ B. Verver. "L'éclassage au gaz à l'eau à Narbonne et L'èclairage au gaz Leprince." Leiden, 1858. See Bromeis. *opus citat.*

|| Heurtebise *Dingl. Pol. J.*, cxxcvi. (?) 393, 1867.

¶ Fayes, *Génie industriel*, 1868, 329. *Dingl. Pol. J.*, clix. 47.

pendent of labor, and of the cost and depreciation of plant, he calculates as follows:—

Per 100 *Cubic Meters of Gas.*

		f.	c.
75 kilometers of coke at 0·03 franc	. .	2	25
55 " coal at 0·025 "	. .	1	37
82 " lime	. . . . .		82
		4	44

The material costs, therefore, $4\frac{1}{2}$ centimes per cubic meter.

Instead of decomposing water by carbon, certain other processes have recently come into use, and require notice.

Lenoir's process,* suggested in 1867, is of very limited applica bility. He decomposed barium sulphide with water, containing sulphate of baryta and hydrogen—

$$BaS + {}_4H_2O = BaSO_4 + {}_4H_2.$$

This process is only practicable where the manufacture of barium sulphate (permanent white) is the main object and the hydrogen a by-product, as was the case with Lenoir.

Tessié du Motay and Maréchal† have introduced a valuable modification into practice, as they require no steam-boiler for the manufacture of the water-gas, and thus economize fuel, whilst the wear of the simplified apparatus is considerably reduced. They heat coal with soda, hydrate of lime or of baryta in iron retorts, and thus decompose the combined water of these bases, which is then freed from carbonic acid in the ordinary manner. This procedure has been adopted by the New York Oxygen Company, who, in the manner de scribed above, sell water-gas at the enormous price of 2 cents per cubic foot, or 1 cubic meter for 3s. 6d.‡ The mixture of lime and anthracite is heated in retorts such as those described above under Tessié du Motay's method of preparing oxygen. The decomposition takes place at a red-heat, according to the equation—

$$C + CaO + CH_2O = CaCO_3 + {}_2H_2,$$

and lasts about fifteen minutes. Thereupon hydrate of lime is reformed by passing steam over the heated mass. The carbon is not ex-

* Lenoir, *Wagn. Jahresber.*, 1867, 219, 259.

† *Bull, Soc Chim*, 1868, i, 334.

‡ H. Vogel, *Ber. Chem. Ges.*, iii, 901.

hausted until after three weeks, and is then replaced by a fresh supply of anthracite.

That coal-gas contains large quantities (30 to 50 per cent.) of free hydrogen, and that the proportion of this ingredient rises the higher the temperature of the retorts in preparing the gas, has long been known. Tessié du Motay and Maréchal, whilst introducing the above-described procedure, have taken advantage of this circumstance, and have passed coal-gas over lime in order to resolve it into carbon, hydrocarbons boiling at high temperatures, and large quantities of hydrogen. At the same time E. Vial* adopted the same method, and has doubled, and even trebled the yield of gas by "decarburation." Schinz† doubts the industrial value of this process, on account of the outlay for fuel, and calculates that the decomposition of water by means of coal yields a luminous gas for half the cost of coal-gas. Here, however, as we shall presently see, the depreciation of the plant has not been taken into account.

If we now inquire in what manner the hydrogen, however obtained is rendered luminous, we find two essentially different methods. The one depends on mixing the water-gas with hydrocarbons. As early as 1834‡ Selligue employed, at Paris, the oils obtained by distilling the marl-shales of Autun in order to saturate the water-gas with gaseous hydrocarbons. White subsequently passed the water-gas through retorts in which rosin or coal was converted into luminous gas, and its process was carefully examined in 1851 by Frankland,§ who concludes a laudatory report with certain propositions, of which the following are the most important:—

1. The production of gas from given weights of common coal or of cannel is increased by 46 to 290 per cent. according to the quality of the material employed.

2. The luminous power is increased by 12 to 108 per cent. the more when coals are employed which produce gas of a highly luminous power.

3. The quality of the residual tar is lowered, a part of it being converted into gas of a strong luminous power.

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* Vial, *Genie Industriel*, 1869. *Dingl. Pol. J.*, cii, 382.

† Schinz, *Dingl. Pol. J.*, cii, 388.

‡ Dumas, "Handbuch der Chemie," vii.

§ Frankland, *Ann. Chem. Pharm.* lxxxii, 48.

It must be remarked that tar had not at that time the value which it has subsequently reached.

White's process recurs, with trifling modifications under a variety of names.

As the "systéme Leprince," or "gas mixture Leprince," it was introduced into industrial concerns at Liege, adopted by the town of Mastricht, and by some departments of the Vieille Montagne at Verviers, and was critically described by Verver in 1848 in his work above quoted. Four years afterwards a similar procedure was elaborated by Baldanus and Grüne,* for which Schaffer and Walcker obtained a patent in Prussia. Their process consisted in passing steam through retorts in which coal-shales, turf, and other combustibles were heated to redness. It differs, therefore, from White's process herein that the production of hydrogen and its carburation are effected in the same retort. An ordinary gas retort 8½ feet in length is said to yield, in twenty-four hours, 8000 to 9000 cubic feet of this gas; and in Wagemann's manufactory at Benel, near Bonn, where this process has been introduced, 1 cwt. of coal-shale was consumed per 1000 cubic feet of gas.

Essentially different is the second method of employing hydrogen for lighting, as carried out in 1846 by Gillard, at Passy, near Paris. He fixed on the burners,† from which the water-gas issued, baskets of platinum wire, which, on the ignition of the gas, were heated to brilliant whiteness. Hence it was called platinum gas (*gaz platine*). The immobility of the light, even in a strong wind, the dispensing with lamp-glasses, which, according to Verver, absorb 22 per cent. of the light, and the brilliance obtained on this principle, must be considered as advantages, although the intensity is not free from objections. Its use was not continued at Passy, but it was introduced by the celebrated firm of Christofle & Co., into their electro-plating works at Paris,‡ and was employed to light the streets of Narbonne. The hourly consumption of gas being 3·234 cubic feet (=0·1 cubic meter), the light was equal to that of 5·22 normal candles, and, though the lamps at Narboone were placed at intervals of 50 meters, Verver pronounced the lighting of the streets as perfect.

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* *Journal für Gasbeleuchtung*, 1862, p. 63.

† Report by O. Henry, *Journ. Pharmacie* [3], xvii, 105; *Dingler's Journal*, cxvi, 222; and the Reports of Bromeis and Ververs.

‡ Wagner. "Handbuch der Technologie," 1873, ii, 371.

Latterly, since the preparation of hydrogen has been improved by Tessié du Motay and Maréchal, new attempts have been made in Paris to light up large squares and streets with "platinum gas." Spectators, however, may find justification for the caricatures in the Parisian comic journals of that time, which represent the passengers in the streets, and even infants in arms, and the very dogs in the gutters, equipped with eye-shades to preserve their sight.

Technical literature has the peculiarity that it records the introduction of novelties, but leaves us in the dark, concerning their practical verification. It keeps a tolerably exact register of the births of inventions, but gives a very imperfect account of their career in life, and of their deaths. Thus, with a single exception, we are left in the dark as to the permanent results of lighting with hydrogen.

The experiments made with water-gas at the town Elizabeth, in New Jersey, yielded unsatisfactory results, as made known in 1865.* Great depreciation of plant, heavy working expenses, and disproportionate consumption of fuel, were the causes of failure.

It was, therefore, the more desirable to ascertain in how far the process had proved successful in Europe, and, thanks to the kindness of several correspondents, we have succeeded in obtaining information. The fate of the method in Belgium, appears from an extract from a letter which M. L. de Koninck, Professor of Chemistry at the University of Liege, kindly forwarded to the present writer:—

The *systeme Leprince*, which consists in the introduction of small quantities of water into the retorts in which coal is distilled, had for a short time, a certain success (*une certaine vogue*), depending mainly on numerous reclamations by which it was helped out. Its chief advantage was supposed to lie in the fact that it drove the gas out of the retort, a purpose for which an exhauster or aspirator is now preferred. The system has never been employed for public purposes in Belgium, but merely in certain manufactories. Since the death of the inventor, which took place some years ago, it is no longer spoken of, and has been generally, if not universally abandoned. This has been the case at Vieille-Montagne.

In a letter dated March 18, 1874, M. Landolt, Professor of Chemistry at the Polytechnic School of Aachen, confirms these statements.

* Wagner, *Jahresberichte*, 1865, 758.

The use of water-gas is continued only in Cockerill's works at Seraing. At Simoni's cloth works at Verviers the process never advanced beyond the stage of unsatisfactory experiments, although certain technological papers have asserted to the contrary. In Maestricht where the water-gas was used for some time for public purposes, it has, as Professor Landolt has been informed, failed to give lasting satisfaction, and has been replaced by coal gas two years ago (1872). Direct inquiries addressed to the municipal authorities have remained unanswered.

The above statement of the introduction of the Drummond light in English military establishments led to an inquiry being addressed to the Chemist to the War Department, Mr. Abel, of Woolwich, from whom the following courteous reply was received, under date April 20, 1874: "As regards your inquiry concerning the introduction of the lime-light in military premises, I have to communicate that at the period you mention experiments were made for a short time in two of our establishments, but that the question of its formal introduction has never been seriously entertained."

The illumination of the galvano-plàstic works of Christofle with water-gas was likewise of brief duration, and the process has been long ago abandoned. We are indebted to this firm for the following communication under date April 21, 1874: "In reply to your letter of the 17th, we have to state that the use of hydrogen in our works came to an end in 1853, on account of certain difficulties (*inconvenients*) which presented themselves, and that we have no longer preserved the documents bearing upon the matter."

It only remained to ascertain the fate of the so-called platinum gas at Narbonne. To do this with certainty there appeared no other method than to appeal to the courtesy of the municipal authorities. The Mayor of Narbonne had the kindness to comply fully with our request, and to sign the following instructive and characteristic letter, dated March 16: "The relations of Prussia and France since the war impose upon me the greatest caution as regards inquiries. As the question, however, is one of a purely scientific nature, I have handed over your letter to the Abbé Prax, chemist to the Agricultural Society of Narbonne, who has for a long time occupied himself with the subject. I have the honor to enclose a copy of the memoir which he placed in my hands."

ACCOUNT OF THE WATER-GAS IN NARBONNE FROM 1855 TO 1865.

"In May, 1855, I was sent to Paris by the municipality to test the water-gas of Passy. My report was dated June 8, 1855. The town adopted this method of lighting and heating and came to an agreement with the company called the 'Narbonnaise.'

"From 1856 the Passy system was in use in Narbonne. We modified the burners in several respects, as those of Passy were not sufficiently lasting. The high temperature of the retorts occasioned from time to time the loss of a furnace, and after many losses the system of retorts was abandoned in favor of another apparatus, the 'Cubilot,' (Faye's apparatus). Towards the end of 1858, it was heated with wood charcoal, which soon gave place to coke, on account of its costliness. At the same time we made important changes in the burners and platinum baskets, the latter of which were suspended instead of resting upon the former.

"The illumination with hydrogen is brilliant but sensitive (*délicat*). The lamps in the streets must be well closed, as a gust of wind distorts the ignited platinum wick. The dust introduces sand, which forms a silicide of platinum, and this metal ultimately assumes an injurious crystalline structure and is even partially volatilized.

"In Narbonne all care was wanting towards the end of the career of the company Narbonnaise. The manager, M. Crouzet, became a wine merchant in Paris. All superintendence was withheld, and the lighting became at last intolerable. In June, 1865, therefore, coal gas was introduced. As far as heating is concerned, nothing can in my opinion compete with water-gas in convenience and cheapness.

"PRAX,

"Narbonne, March 15, 1874. "*Chemist to the Agricultural Society.*"

Ballooning had been made subservient to the purposes of meteorology and physics before it was enlisted in the service of the war-spirit. Charles utilized his expedition for scientific purposes. On July 18th, 1803, he was imitated by Robertson, who ascended from Hamburg to the height of 7400 meters, and who imagined that he perceived at this altitude a decrease in the intensity, not merely of terrestrial magnetism, but also of frictional electricity. These statements induced the great physicists, Biot and Gay-Lussac, to undertake two ascents the next year. They refuted the above mentioned views of Robertson, remarked the decrease of atmospheric moisture with

increasing altitude, and made numerous and valuable meteorological observations. From the greatest height which they attained, 6500 meters, Gay-Lussac brought back a specimen of air, and found that it had the same composition as the air of lower regions—a result at that time, of capital importance. The last mentioned ascents were all made with hydrogen gas. As the use of gas-lighting became more and more general, the greater power which the lightest of all known bodies offers was sacrificed to the convenience which coal-gas afforded. In France, Barral and Bixio made their scientific ascent in 1850 with the aid of coal-gas. In England, Glaisher adopted the same plan in 1864; and the numerous balloon voyages which have been made for the amusement of the public, from the love of adventure, or for some especial purpose, have been undertaken with the same material. With coal-gas, Green traveled in sixteen hours, from London to Weilburg, in Nassau, in 1836; Flammarion and Godard in 1867, from Paris to Solingen, performing 70 German miles in twelve and a half hours. Nader, who hoped to take photographic maps whilst floating in the air, had filled his balloon "Le Géant," with 6000 cubic meters of coal-gas, on his somewhat dangerous journey from Paris to Hanover, October 18th, 1863. More recently aeronauts have returned to the use of hydrogen. But even in those four months of the greatest siege of a metropolis of which history bears record, when Paris depended exclusively for its intercourse with the outer world upon carrier pigeons and balloons, which had never before been called to so important a service, even then necessity compelled the use of coal-gas, because it was procurable with the least difficulty.* 65 balloons went up from Paris between September 28th and January 22d, carrying 91 passengers, 363 pigeons, and $2\frac{1}{2}$ million letters, and for the most part with success. Only five balloons fell into the hands of the German armies; one descended in Munich, another at Wetzlar, one disappeared entirely, perhaps in the sea, whilst the fragments of another were found in the autumn of 1873 clinging to a tree at Port Natal, in southeastern Africa. All the others descended safely beyond the radius of the besieging army in France or upon neutral territory; one in Belgium, three in Holland, and one upon a snow-field in Norway, sixty (German) miles to

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* Saint-Edme, "La Science pendant le Siége de Paris," 1871, 62.

the north of Christiana, and one hundred and eighty from Paris, which had been traversed in fifteen hours.*

At that time, the power of steering balloons was more than ever felt to be necessary. Many of Montgolfier's contemporaries, including well-known physicists and mathematicians such as Meusnier, Monge, Lalande, etc., had pronounced this problem to be practicable. Fruitless and partially absurd attempts at its solution were not wanting. The celebrated inventor of the injector, Henry Giffard, was not deterred from carrying out new experiments in this direction, in the year 1852, and the most recent attempts are based upon his ideas and those of Meusnier. Instead of the ordinary form, Giffard gave his balloon the fish-like shape of a ship, for the convenience of steering. A steam engine, with its chimney turned downwards, to obviate the risk of fire, and whose steam was simultaneously employed to maintain the draught, turned a screw sufficient to turn the balloon, but certainly too weak to overcome the strong wind, which, on September 25th, drove Giffard's aerial ship before it. Public opinion then turned in favor of a project of aerial navigation opposed to all previous methods. Ponton d'Amecourt, De la Landell, and Nadar, wished to attempt by mere mechanical force, without the aid of light gases, to navigate the air in all directions. The authority of Babinet suppported this scheme, which, however, according to Helmholtz,† had no sound physical basis, and which, when carried into execution, proved a failure.

When the Paris Exhibition of 1867 drew general attention to every industrial advance, Giffard received a commission to make aeronautics available for the "million" by means of a hydrogen balloon. He constructed a balloon of 5000 cubic meters capacity, the inflation of which, with hydrogen generated by iron and sulphuric acid in wooden casks, cost 5000 francs. The gas was subsequently prepared by him for a twentieth part of the cost of conducting steam over ignited charcoal, a method of which Coutelle had made use in 1794. The balloon was attached to a wire rope, 300 meters in length, and was very skilfully secured. A steam engine of 50 horse power uncoiled the rope, and drew down the balloon with its passengers, when the

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* Stephan, *Weltpost und Luftschiffahrt.* Berlin, 1874.

† Helmholtz, *Berl. Akad. Ber. u. Verhand d. Ver. für Gewerbfleiss in Preussen,* 1873, 326.

permitted height had been reached. This height was not great enough to occasion any danger from the expansion of the gas; hence Giffard was able to close the balloon with valves instead of leaving it open below. Thus, the loss of gas by diffusion did not exceed 15 cubic meters daily, and was easily replaced at intervals of three days.

The next impulse to aeronautics was given, not by festivity, but by the terrors of war and the siege of Paris. The Académie des Sciences commissioned one of its members, Dupuy de Lôme, to make experiments on steering balloons, and the government furnished the requisite means. Dupuy gave his balloon the fish shape,* and in order to render its shape stable in the wind, he fitted it with an internal secondary balloon (*ballonet*), containing more or less air, and equal in bulk to one-tenth part of the main balloon. The air could be let out of this inner balloon by valves, or driven in again by means of a bellows in the car, according to a plan which Meusnier had devised as early as 1783, to supersede the use of ballast. Dupuy's balloon was further distinguished by a very firm method of suspending the car, and by the use of a varnish impermeable to gases, and made of gelatine and tannin dissolved in pyroligneous acid. The propelling screw was not turned by a steam engine, but by eight men in the car. The balloon, containing 3450 cubic meters, was filled with hydrogen obtained from iron and suphuric acid, and went up at Vincennes, on February 1st, 1872, carrying fourteen persons. After a flight of two hours, it was let down at Noyon, a distance of 106 kilometers. By means of an anemometer, Dupuy was able to determine the independent speed of the balloon at 2·82 meters per second, whilst that of the wind was 16 to 17 meters, and the course of the balloon made an angle of 12° with the direction of the wind. The problem of steering had, therefore, been solved, though only to a very slight degree—sufficient for a calm, but insufficient for overcoming even moderate winds. The speed attained was slight. Both conditions of success depend on the employment of stronger sources of mechanical power, and this, again, requires an increase of its power of ascent, *i. e.*, of its relative levity with an enlarged volume.

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* Dupuy de Lome, "Note sur l'Aerostat." Paris: Gautier-Villars, 1872.

(To be continued.)

ON FORMATION OF CLOUD IN RAREFIED MOIST AIR.*

When a given quantity of air, saturated with water-vapor, is suddenly rarefied, a part of this vapor (it is known) is precipated as cloud, in consequence of the fall of temperature. In a paper recently contributed to the *Journal de Pharmacie et de Chemie*, M. Conlier states that to render this phenomenon more apparent he procured a large zinc tube 3 meters in length, and closed the ends of it with glass discs. He introduced a little water, compressed the air present, for a little, and then opened a cock at the side, so relieving the compression. Thereupon appeared a pretty thick cloud, through which the outline of a candle-flame could not be perceived. Having, after some days, however, repeated the experiment, he found that it did not always succeed; and he set himself to find the reason of this.

With this view, he obtained a three-necked flask, the bottom of which was covered with water. Two of the necks were furnished with cocks, while the third was connected by a caoutchouc tube with a balloon of caoutchouc, the compression of which, when both cocks were closed, produced an instant compression of the air in the flask; on removing the pressure, the air expanded again, and a cloud was formed in the flask. The cloud spherules thus produced were of various sizes, and were in constant motion. On looking at a flame through the cloud, one observed the well-known colored rings.

Hitherto the formation of these clouds has been explained by precipitation of water in consequence of cooling. The following experiment shows, however, that this explanation is not exact. If the flask is allowed to stand some time undisturbed, the phenomenon is not obtained. Under circumstances that are apparently exactly the same as those of the experiment at first, the air remains perfectly clear. To explain this fact it must be supposed that this air has been altered in composition, and has lost a constituent, which gave it the property of becoming troubled in expansion. This element seems to be soluble in water; for if you vigorously shake the flask when it contains the cloud-giving air, the air becomes inoperative.

Carbonic acid, oxygen, and various other gases, are without influence on the phenomenon. In the water at the bottom of the flask no new constituent could be discovered. If it be wished to repeat

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* From *English Mechanic*, London, December 17th, 1875.

the experiment with a flask that has become inoperative, there is nothing for it but to remove the inclosed air, and substitute external air. Thereafter the cloud is readily obtained. M. Conlier now conceived the idea of filtering the air before it entered the flask ; an operation easily effected by first squeezing the balloon, and so forcing out a portion of the air, and then placing before the cock, through which air must again enter, a plug of cotton wool. The air thus admitted was found to be *inoperative*. The filtering had taken away from it the power of giving a cloud.

This remarkable action of the filter had led to the hypothesis that the air contained certain fine, solid particles, which occasioned the formation of cloud. These particles were held back by the filter. In the case of the vessel remaining several days at rest, they fall to the bottom, and remain in the water. And in a similar way, shaking the flask makes the air inoperative. When the air is completely free from these floating particles, a slight expansion produces no cloud ; the air rather remains in a measure super-saturated. When, on the other hand, a solid particle floats in the air, this causes the liquefaction of the vapor ; it acts like a nucleus for the water-vesicle, or droplet, and the cloud is immediately formed. This explanation became the starting-point for further confirmatory experiments.

If a small quantity of tobacco or other smoke be brought into the flask—so small that it does not perceptibly trouble the air of the flask, it makes it uncommonly sensitive.

On the other hand, to render inoperative the dust which brings about the formation of cloud, it might previously be burnt. For this purpose, the air before being admitted to the flask was strongly heated in an unsooty alcohol flame ; but, contrary to expectation, the air so treated proved even more operative than ordinary air. The reason of this soon appeared in the fact that the air passing through the flame took up carbon particles, which served as nuclei for the cloud formation. Mr. Conlier, indeed, found that even the quite unsooty flames give gases, which, on being filtered through cotton wool, color the parts of this that are first encountered black, or at least gray ; indicating that they contain fine particles of carbon.

An estimation of the amount of carbon dust which could make the air in the flask operative, gave the value of $\frac{1}{14400}$ milligram.

M. Conlier inclines to the belief that the carbon particles which are always mixed with the normal Paris air, are in general the op-

erative cause in the phenomenon of cloud formation; and he utilizes the greater or less formation of cloud, in a flask like the one described, as a rough scale of measurement for the quantity of dust in the air.

From numerous and repeated experiments he found that the external air is never wholly inoperative. Great differences could be perceived, however, the cloud obtained was more or less stable; it disappeared, in many cases faster than in others. A pretty continuous rain and snow appeared to hinder the cloud formation; so did bad weather with strong winds; a moderate amount of cloud seemed not to increase the activity of the air. In summer of this year, the air was somewhat less operative than in winter, 1874.

M. Muscart, who has repeated these experiments, finds that other liquids besides water, viz.: alcohol, benzine, etc., give similar actions He finds strongly ozonized air very operative, and in this case the cotton wool filter was not capable of robbing the air of its activity. "This action of ozonized air," he says, "cannot be explained by the experiments adduced; it proves that various circumstances may make the air active, and that this activity, though mostly depending on the mechanical action of particles floating in the air, can also be called forth by other causes."

MEANS OF DISTINGUISHING FERMENTS.

Abstract, by C. B. Dudley, Ph. D.

In the July number of *Annales de Chimie et de Physique*, M. A. Müntz, gives some interesting statements in reference to ferments. Assuming that fermentation is caused by two different kinds of ferments, viz.: (1). Minute organisms endowed with life, and (2). Unorganized nitrogenous substances; he gives a means of distinguishing between these. According to his statement, fermentation, which takes place as the result of the presence of minute living organisms, is completely and entirely prevented by the addition of a few drops of chloroform, while the same substance has absolutely no influence upon the action of the unorganized nitrogenous ferments. As a proof of this, ten different experiments are cited, five to establish the first point, and five the second.

(1). Five cubic centimeters of chloroform were added to 200 c. c. of milk. The liquid remained four months without thickening, and no organisms showed themselves.

(2). Two hundred c. c. of fresh urine with 2 c. c. of chloroform, remained two months at a temperature from 25° C. to 30° C., without undergoing ammoniacal fermentation, and as before, no organisms appeared.

(3). Ten grains of cane sugar, dissolved in 200 c. c. of water, in presence of chalk, cheese, and of 3 c. c. of chloroform, did not show lactic fermentation at the end of four months, and again no organisms took birth in the liquid.

(4). Flesh, gelatine, starch and other similar substances, in presence of water and a small quantity of chloroform, remained for three months without change, in spite of a temperature of about 30° C, to which they were submitted. No living being, either animal or vegetable, could be found in the liquid.

(5). The alcoholic fermentation of sugar, in presence of brewer's yeast, is completely arrested from the moment when chloroform is placed in the liquid.

To show that chloroform has no influence whatever upon the nitrogenous ferments, the following experiments are given:

(1). Two grains of dry, sprouted barley, containing originally 50 milligrams of glucose, were put into 40 c. c. of water and 5 c. c. of chloroform. At the end of 50 hours, 520 milligrams of glucose had been formed. In a parallel experiment, without chloroform, 540 milligrams of glucose were developed in the same time.

(2). Ten grains of oil-cake of bitter almonds, containing originally 6 milligrams of Prussic acid, were placed in 300 c. c. of water and 5 c. c. of chloroform. At the end of 70 hours 32 milligrams of Prussic acid had been formed. In a parallel experiment, without chloroform, 32 milligrams of Prussic acid were formed.

(3). A solution of starch, containing originally in 100 c. c. 15 milligrams of glucose, was placed in contact with saliva and chloroform in large quantity. After 15 hours, 100 c. c. of the solution contained 120 milligrams of glucose. One hundred c. c. of the same starch solution, treated with saliva, but without chloroform, yielded in the same time, 110 milligrams of glucose.

(4). Some mustard seed flour, which contained only traces of vola-

tile oil, placed in contact with water and chloroform, developed as strong an odor as that from the flour treated with water alone.

(5). One hundred c. c. of a solution of cane sugar, containing 5 per cent. of sugar, showed in a sacchariceter 33° to the right. Three grains of yeast and five drops of chloroform were added. Not a bubble of carbonic acid was disengaged, and yet, at the end of 48 hours, the liquid showed in the sacchariceter 9·5° to the left. In this experiment the yeast produced its chemical action, viz., inversion; but alcoholic fermentation did not follow.

If these experiments are to be relied on, Pasteur's theory that all fermentation is the result of the action of living organisms, would still seem to need confirmation.

A CURIOUS CASE OF MAGNETIZATION.*

By M. J. Jamin.

A bar of steel may be magnetized to saturation by a very powerful current, and to one of the halves may be given a southern magnetization, which I shall call *positive*, and which extends to the very centre or heart of the bar. This being done, I submit the bar to a current in the reverse direction, weak at first, but gradually increasing, which produces a northern or *negative* magnetization, limited at first to the surface but penetrating afterwards to an increasing depth, always leaving, however, layers of positive polarity underneath. The effect observed is but the result of the difference of action of the two magnetizations superposed one over the other, as manifested externally. It is first positive, then neutral, and finally negative. I stop directly the change of sign is apparent.

I afterwards dissolve the steel in acid, and it is evident that I thus remove little by little, the exterior northern or negative layers, and expose the underlying southern ones; that the magnetization observed is at first negative, then diminishes, becomes neutral, and then changes the sign.

I have now to add that the southern layers are not laid bare throughout at the same time. They commence to show themselves at the end, and especially at the edges and corners as points, very sharp, and of

* From the *Comptes Rendus* of the Academy of Sciences, Paris.

very small extent. They have then a great tension, but their magnetic momentum is small, because they occupy a very small surface. At the same time there exists a northern layer extending uninterruptedly from the end to the mean line; this is the remainder of the exterior layers which have not yet been eaten away by the acid. The intensity of the latter is almost nil at any given point, but the surface being large the quantity and momentum of this northern magnetism are considerable, more considerable than the quantity and momentum of the southern points which protrude at the very end; it follows that this half of the bar turns to the south as if these last mentioned points did not exist.

Let us bring forward gradually the southern pole of an ordinary magnet; whilst it is at some distance, it is subject to the predominant influence of the northern layers of our bar, and is attracted, but if it is brought to the end of the bar, it comes very near to the southern points, which are situated at the end, the force of the latter prevails, and repulsion takes place; thus we have attraction at a distance and repulsion upon contact; and, what is no less curious, upon contact, repulsion of the extremities which turn to the contrary poles of the earth, and attraction of the extremities which turn to the same side. At a sufficient distance, the direction of the effects changes, and everything takes place in the accustomed order.

HOW TO EXTEND THE CAPABILITIES OF A LANDSCAPE AND COPYING LENS.*

There are few photographers who do not frequently feel the necessity for a far greater elasticity, so to speak, in the apparatus employed by them when out afield in the prosecution of their pictorial labors. This elasticity, or increase of accommodation and power, is especially desirable in respect to the lens employed; for circumstances very often arise which cause a lens suitable for the general course of work to become unsuitable on special occasions.

To meet the exigencies which thus so often arise, landscape photographers now rarely go from home without more than one lens; for it is obvious that, if the object to be photographed appear too small and insignificant upon the ground glass when using a lens of a certain focal length, two ways only remain by which this dwarfed appearance

* From the *British Journal of Photography*, Nov. 12th, 1875.

can be remedied, namely, either by going much nearer to the object in question, or by substituting a lens of much longer focus for that by which the image was projected upon the ground glass. The former is often artistically impossible when once the view has been carefully composed and selected; for the perfection of the picture may depend upon the relation certain portions of the scene—such as rocks, trees, or foreground objects—bear to the main object, and the alteration of the point of view might be entirely subversive of such harmonious composition. The latter implies the possession of such a variety of lenses as will meet cases of difficulty of this kind as they occur. By far the best plan is for the tourist photographer to travel with lenses of various foci; for he can, under such circumstances, select his view with the greatest care without regard to the general capabilities of the lens, which he will then select from his stock with special reference to its peculiar attributes for accomplishing the work laid out for it by the photographer.

While such is the best mode of securing the object in view, it is, however, one in which the amateur of moderate means dare not freely indulge, on account of the large expenditure involved. It is our object here to indicate in what way the possessor of one good lens may be able to utilize it for divers kinds of work, by varying its focus within a considerable range, and thus producing a small, large, or medium sized picture at will.

It is well known that any of the cemented, non-distorting combinations now so much used may also be employed in the single form; that is, the back or front lens of such a combination may be used alone. In this condition it is double the focal length of the complete combination, and covers a plate of twice the dimensions capable of being covered by the other; but when employed in this way it is not adapted, when worked up to its full covering power, for architectural subjects, owing to its curving the straight lines of the building delineated near the margin of the picture. When, however, skill is exercised this kind of curvature is not noticeable—a fact amply proved in a very large and excellent picture of *Kirkstall Abbey* we recently received from Mr. Wormald, of Leeds, in which, owing to his not having an objective of sufficient focal length, the posterior element of one of his combinations was pressed into service.

We shall now show by what means the focus of such combinations may be varied to a great extent without introducing any linear dis-

tortion; but before doing so we must remind the reader that the correction of a photographic lens is only a compromise, some inactive rays being brought to a focus along with those of most activity, although some of the latter class are left outstanding. We shall take as the lens on which the following experiments and remarks are based one of those now so well known respectively as the "rectilinear," the "symmetrical" and the "Steinheil aplanatic," this particular class of instrument being most rapid in action. When a lens of this order is used in its complete form—that is, as sent from the maker—it covers a plate of certain dimensions without any diaphragm; but by using a small stop the covering power is extended and the area of sharp definition increased. If now a series of very weak concave lenses be obtained (those by means of which we have conducted a large number of experiments were spectacle lenses for short sights), and if one of these be inserted midway between the lenses of the photographic combination, the focus, and, consequently, the covering power, will be greatly increased. To give an instance: we possess a lens coming under the category above named, purported by the maker to cover a 6×5-inch plate. In total disregard of its maker's suggestion, we have invariably used it for plates $7\frac{1}{2} \times 5$; and when employed with a small stop the back lens alone will cover 12×10—with, of course, a curvilinear distortion when applied to architecture on a plate of such dimensions. With a view to converting it temporarily into a 12×10 *non-distorting* instrument, we selected a concave lens of the cheap class already indicated—the strength of this lens being such as nearly to neutralize one of the achromatics of the combination—and inserted it in the position of the diaphragm. The effect was that the focus of the combination was immediately doubled, with absolute freedom from distortion. When taking a picture with it in this altered condition, we found it necessary to use a small stop, as the field was now over-corrected for flatness; but what we scarcely expected to find was the fact of the lens working to visual focus—a fact at which one's wonder ceases when it is considered that, as we have already said, photographic correction of color is a compromise.

From the foregoing, and from several other experiments of which that given is a type, we draw the conclusion that a photographer with only one lens may greatly extend its capabilities at a small cost by having its mount so altered—presuming Waterhouse stops are used—as to render it possible to drop in one of a series of diaphragms made

as follows:—Provide three or four of the weakest concave spectacle lenses produced, but of progressive strength, and chip them down to about the dimensions of a shilling. When of this diameter they will be very thin. Next attach each of these little lenses to a brass stop of the ordinary Waterhouse form, adopting such means as will be suggested to any one possessing a mechanical turn of mind—the best in our estimation consisting in soldering upon the stop a very shallow ring of brass sawn from the end of a tube, the depth being such as to leave it on a level with the edge of the lens. A series of these lenses thus fitted ready for insertion can be carried in a diaphragm pocket-case having divisions to prevent them coming into contact one with the other; and, after the value of each, as respects the additional lengthening of the focus of the combination, has been engraved or scratched on the brass portion of the stop, a photographer who goes to the country with such an adjunct to his lens will find himself enabled to secure effects which without such assistance would be impossible, while, at the same time, the good qualities of the lens as it issued from the hands of its maker are still preserved intact.

What has been said as regards the lengthening of the focus by means of a *concave* lens applies equally to the shortening of it by the expedient of using one of a convex form.

A FEW INSTANCES, SHOWING THE POSSIBILITY OF APPLYING THE MICROSCOPE TO INORGANIC, QUALITATIVE ANALYSIS. A THESIS.

By Frank W. Very.

Preface.—The researches narrated in this paper, have been limited by the low power of the microscope used, and by the shortness of the time which could be given to such work. The first cause has obliged us to throw aside many precipitates (often most delicate tests for the substance under consideration), which could perhaps be made available by means of higher magnifying power.

It is the author's opinion, that a method can be devised for carrying on a complete qualitative analysis by means of the microscope,

with the use of appropriate reagents; but to discover the tests, which are best fitted for the purpose, and which give the most distinctive crystals, under conditions that may be defined, is a labor of years.

Such a method would be of especial use where only a limited quantity of a substance could be obtained, as in the case of rare minerals, a single small crystal would be sufficient for an analysis. Or it might become of use in the examination of the residue left by the evaporation of mineral water.

In its present state, the method does not seem to be as delicate as the ordinary one; perhaps it can never be made so. The matter which causes a perceptible cloudiness in a large mass of liquid, may be so finely divided, that the microscope would fail to recognize the form of the particles. On the other hand, the microscope will probably have the advantage of rapidity in the prosecution of the work. In many cases it will enable us to recognize one or more elements in the presence of others, which in the ordinary method would have to be removed first.

The few tests which are herein described, can hardly be called very successful. There are doubtless much better ones to be discovered. They will serve, however, as a basis for further investigation, and the general considerations deduced from them will always be of use.

General Directions.—It would be best to use an inverted microscope for these researches, because strong acids could then be applied as reagents without injury to the objective from their fumes. In this case, thin glass slides must be used. These can best be made by cutting a hole in an ordinary slide, over which a piece of thin glass is cemented.

Small test-tubes or phials, two or three inches long, are convenient for holding reagents and the solutions to be tested. A drop of the liquid may be removed from these by means of a glass rod; or if more of the liquid be needed, a pipette, made of a capillary tube, may be used. In either case, the utensil should be washed at once, and a basin of water should be kept at hand for this purpose, and for washing the slides.

There ought to be several tests for each element, to act as checks, and we can the better afford this since a single test often shows two or three elements at once.

When precipitations are in order, it is a safe rule to have the solutions tolerably dilute, provided the precipitate is sufficiently insoluble. The precise amount of dilution must be determined for each case by experiment. Unless this be done, the crystals come in such confused masses that they are hard to distinguish. Extremely insoluble precipitates are generally very finely divided. Here dilution is absolutely essential, if recognizable crystals are to be obtained. Even very great dilution does not always succeed in bringing this about. In dilute solutions it is often necessary to wait a while for the crystals to form: and, in very many solutions, the formation of crystals is facilitated by agitating the liquid with a stirring rod. As the latter scrapes against the glass slide, the crystals fall in its track in thickly set rows. The crystals produced in this way are generally smaller than they would otherwise be, but are more perfectly formed.

In the production of crystals by evaporation, the liquid must necessarily be concentrated; and the serried, interlacing forms produced in this manner are often difficult to recognize, especially as they are apt to vary considerably. Hence precipitations are generally more desirable than evaporations. However, some substances can be readily recognized from evaporated preparations, particularly if the same conditions of temperature, and so forth, are used in every case; but there is generally an element of uncertainty, because the other substances, which may be in solution, are apt to influence the form of the crystalline aggregation.

Some solutions evaporate well enough spontaneously, but generally a slight degree of heat is necessary. If the heat is applied merely to concentrate the liquid, it need not be noted: otherwise the thermometer should be consulted. Very good results may be obtained, even with deliquescent substances, by evaporating under the receiver of an air-pump, over sulphuric acid; but this is a rather slow operation. To prevent the crystals from interlacing too thickly, the slide may be canted a little, so as to leave a very thin layer of liquid on the upper edge of the drop. Evaporation will here go on very rapidly, and the crystals will be farther apart.

The precipitation of a substance may often be effected by the addition of a liquid, in which it is much less soluble, provided the solution is already sufficiently concentrated. Several examples of this

will be mentioned. The common solvents, water, alcohol and ether, will be the ones most used in this way.

In evaporation, as well as in precipitation, the crystals should be watched from the commencement of their formation, as they are then more distinct, and afterwards become too much intermingled.

There is undoubtedly a general family resemblance between the various dentritic forms in which the same substance is wont to crystallize under slightly different conditions or on different occasions; but it is very hard to analyze these resemblances, and to state wherein they consist.

The same saline solution, evaporated under the same conditions of temperature, will give crystalline forms which vary remarkably. The multifarious shapes which snow-flakes take, are well known. Perhaps, if we were as well acquainted with other substances, we should find a similar diversity; although water is such a wonderful substance in many other respects, that it would not be surprising if it should surpass all others in the variety of its crystalline forms. It would be interesting to note the variation of a single substance (as $Ba\ Cl_2$, for example), when evaporated under different conditions of temperature, pressure and atmospheric humidity. Perhaps the passage of an electric current would influence the phenomenon.

The deposition of metals upon the passage of an electric current through their solutions, is well observed under the microscope. The crystallizations generally take the form of trees, like those produced when similar experiments are tried on a larger scale, as in the formation of the well known lead and silver trees.

To obtain these metallic crystals, two strips of platinum foil are fastened to the upper surface of the slide with shellac, leaving a distance of three or four millimeters between their free ends. The other ends of the platinum strips communicate with the poles of a battery. The drop of liquid being placed on the slide, so as to connect the platinum terminals, the metallic tree begins to advance slowly from one of these, moving faster, however, as it approaches the opposite electrode; because the resistance to the current becomes less as the distance which it has to travel lessens.

There is a decided difference between the crystallizations of the various metals, yet it would be difficult to recognize them if mixed together; because the differences, though decided, and quite con-

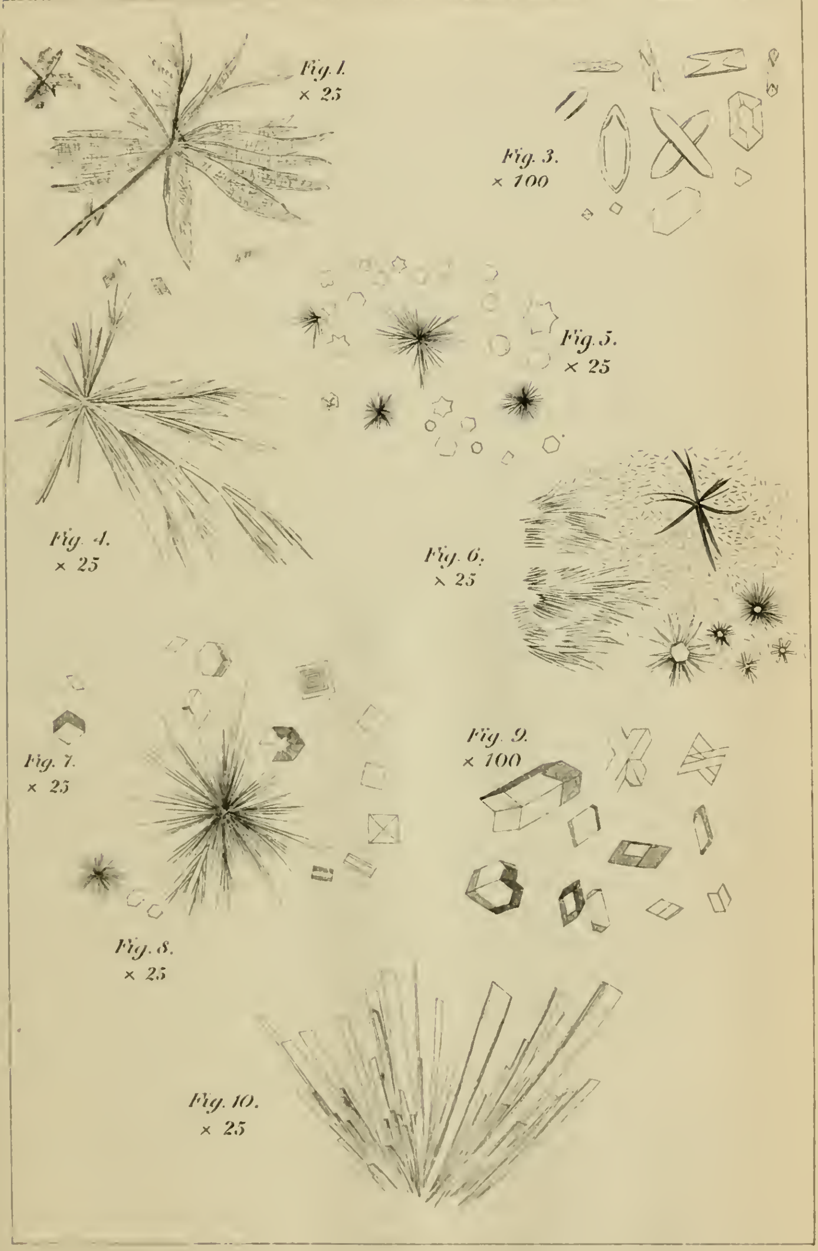
Fig. 1.
× 25
Fig. 3.
× 100
Fig. 5.
× 25
Fig. 4.
× 25
Fig. 6.
× 25
Fig. 7.
× 25
Fig. 9.
× 100
Fig. 8.
× 25
Fig. 10.
× 25

stant, are very slight, and it is hard to recollect the precise degree of complexity of the interlacing feathery fibers.

Special Cases.—Scheme for detecting Lead, Bismuth, Copper and Cadmium, in presence of each other :

Precipitate the metals as carbonates with sodic carbonate. Wash the precipitate.

I. Dissolve a portion of the mixed carbonates in nitric acid. (N. B. The concentrated reagents are always meant, unless otherwise stated.) If much lead is present, a portion of plumbic nitrate will remain undissolved.

a. To one drop of the liquid add water. The basic nitrate of bismuth will be precipitated in beautiful radiate bunches of plates (Fig. 1, Plate I), which are easily recognized. When the water is added, there is first a very fine precipitate, in the midst of which the radiating bunches appear, and increase in size while the first precipitate disappears.

b. To another drop of the solution add alcohol. Dendritic crosses, formed by three bars intersecting at right-angles, will be formed, (Fig. 2, Plate II). Plumbic nitrate is precipitated in this manner by alcohol.

II. Dissolve a portion of the carbonates in chlorhydric acid. If much lead is present, it will be at once re-precipitated as chloride. In this case, pour off a portion of the supernatant liquid. (See *b.*)

a. To prove the presence of lead, add water to the precipitate, and dissolve by the aid of heat. Plumbic chloride will crystallize on cooling, as represented in Fig. 3, Plate I.

b. Evaporate the solution at a very gentle heat (about 50° C). Cupric chloride will crystallize first in long, branching needles (Fig. 4, Plate I), considerably coarser than those of Cadmium chloride, which is deposited next in bunches of fine radiating needles and hexagons, (Fig. 5, Plate I). Many of the latter have incurved sides, and these seem to be quite distinctive.

Sometimes the convexity is outwards, and then the outline of the crystal often approaches that of a circle. When only perfect hexagons are seen, these cannot be distinguished with certainty from those of bismuth chloride (Fig. 6, Plate I); although the latter, being somewhat deliquescent, require more time for their formation, and are often the centres of radiating, acicular bunches.

In the presence of Bismuth chloride, the existence of Cadmium should be verified by forming its double chloride with potassium, (Fig. 7, Plate I). By evaporating a drop of the solution, simply placed in contact with one of potassic chloride solution without stirring, the crystals of double chloride appear only on the dividing line, as in Fig. 8, Plate I.

III. Dissolve a portion of the precipitated carbonates in acetic acid. The carbonate of copper dissolves quickly with effervescence, and, if in large quantity, is at once deposited again in beautiful, deep blue crystals of the monoclinic system (Fig. 9, Plate I), often forming twins, which fall in heaps in the track of a stirring rod. The other carbonates dissolve quite slowly ; and, being very deliquescent, do not crystallize when the solution is evaporated at a gentle heat.

Scheme for distinguishing Barium, Strontium and Calcium, in presence of each other :

Precipitate the group by ammonic carbonate. Wash and dissolve the precipitate in chlorhydric acid.

I. Let a drop of the solution evaporate spontaneously. The chlorides of Barium, Strontium and Calcium can often be recognized in this way. The chloride of calcium crystallizes in large, radiating prisms with oblique ends, (Fig. 10, Plate I). It is a beautiful sight to see the finer, moss-like forms of strontic chloride (Fig. 11, Plate II), creeping across the field, or the more branching, dendritic crystals of baric chloride, which often come down in four or six-rayed stars, as do these of strontic chloride occasionally. The latter, however, generally forms a 60° cross, while baric chloride has the arms more frequently at an angle of 90°, and more profusely branched. But there is nothing very definite in these, and we have seen the greatest variety in the crystallization of baric chloride of any substance tried.

II. To another drop of the solution add alcohol. Baric chloride comes down in dense heads (Fig. 12, Plate II), reminding one of the ripe heads of dandelions, although the resemblance would not hold good when minutely examined. The first precipitate is sometimes followed by bundles of irregular plates, (Fig. 13, Plate II).

In the absence of calcium, alcohol precipitates chloride of strontium in fine needles, separate, and also in stellate bunches, (Fig. 14, Plate II). These soon dissolve as the alcohol evaporates, and are succeeded by rhombuses.

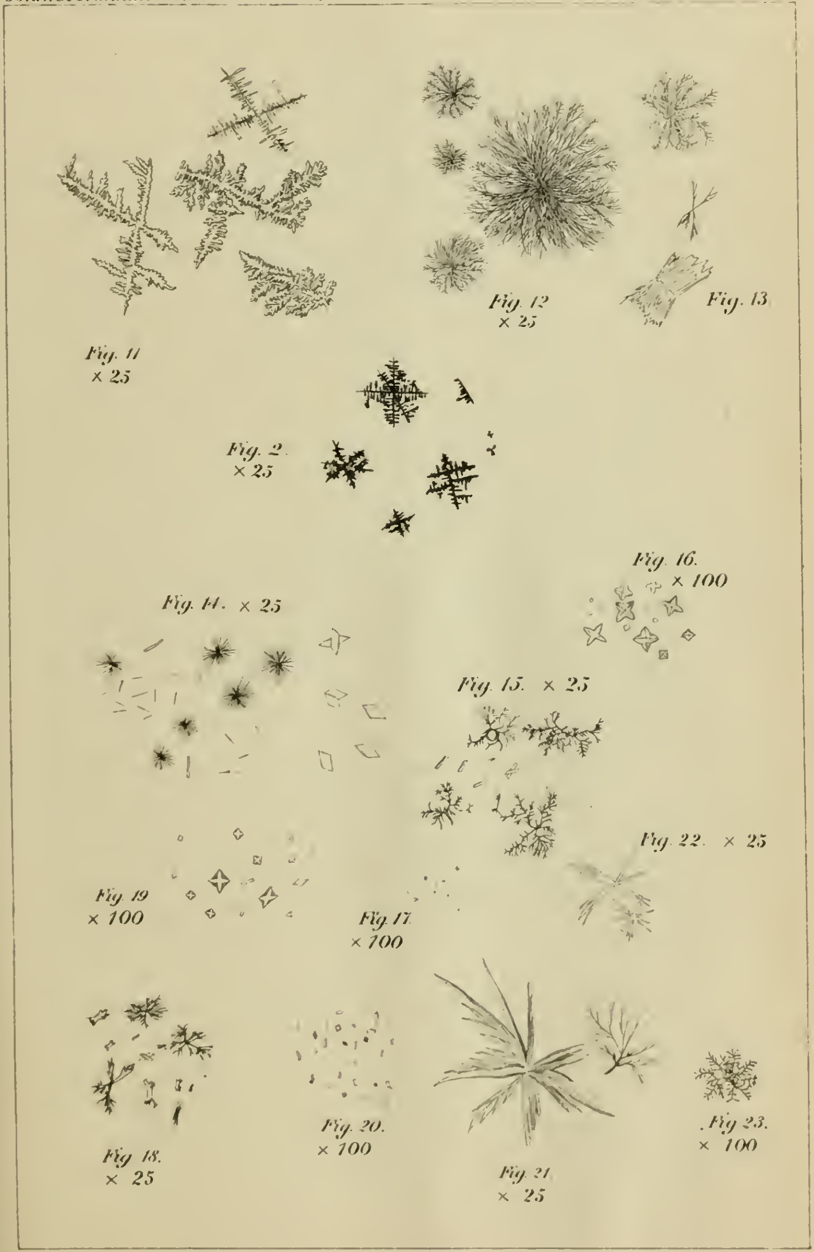
Fig. 11 × 25
Fig. 12 × 25
Fig. 13
Fig. 2. × 25
Fig. 14. × 25
Fig. 16. × 100
Fig. 15. × 25
Fig. 22. × 25
Fig. 19 × 100
Fig. 17. × 100
Fig. 18. × 25
Fig. 20. × 100
Fig. 21 × 25
Fig. 23. × 100

Calcic chloride is not precipitated by alcohol.

III. Dilute a portion of the solution, and add ammonic oxalate (1-1000 N. S.). It is necessary to wait a short time for this reaction, as the first precipitate is very finely divided, but is gradually succeeded by another one, which is much coarser, particularly in the case of barium. The first finely divided precipitate of baric oxalate will entirely disappear in the course of ten or fifteen minutes, and will be succeeded by branching forms (Fig. 15, Plate II), looking sometimes like a deer's antlers. Strontium is precipitated in pointed crosses (Fig. 16, Plate II), while the oxalate of calcium (Fig. 17, Plate II) is too fine to be recognized with a $\frac{1}{4}$ objective.

Add enough chlorhydric acid to the precipitated oxalates to dissolve them. Then neutralize with dilute ammonia water. The oxalates will be thrown down again, but will have a slightly different aspect, as represented in Figures 18, 19 and 20, Plate II.

IV. An alcoholic solution of picric acid produces a precipitate in the aqueous solution of the chlorides, for the picrates of this group are all insoluble in alcohol. However, the picrates of barium (Fig. 21, Plate II) and of strontium (Fig. 22, Plate II) differ only in size; and the feathery picrate of calcium (Fig. 23, Plate II) does not always come down with sufficient clearness to be distinguished.

V. In the reactions which we have tried thus far, calcium has given the finest precipitates, and the ones most difficult to recognize. All this is reversed when we come to the sulphates. The precipitates of baric and strontic sulphates are too fine to be recognized, while sulphate of calcium forms large, radiating, acicular bunches, something like those in Fig. 14, Plate II, but much thicker. To obtain these, dilute sulphuric acid (1-100 N. S.) is added to the solution of the chlorides. The sulphate of calcium will not come down at once, if the solution contains but little calcium. Upon evaporation, however, the crystals will appear. In the presence of much barium and strontium, it may be necessary to use a more dilute solution, so that the dense cloud produced by the very minutely divided sulphates of these elements, may not obscure the calcic compound.

In conclusion, it may be remarked, that the value of these methods has been tested by the successful analysis of such solutions as would occur in practice.

FREEZING MIXTURES.*

The numerous and varied applications which ice has found in these times have greatly enhanced the importance of that product, and, while large portions of it have annually been transported from the colder to the hotter regions of the globe, scientific ingenuity has attacked, energetically and successfully, the problem of producing cold by artificial means for industrial and other purposes. In a recent number of *Dingler's Polytechnisches Journal*, Professor Meidinger has an instructive paper, giving an account of the progress made in recent years in the art of ice manufacture.

There are three ways indicated by physics in which temperature may be lowered, and ice formed—viz : solution of solid substances, evaporation of liquids, and expansion of gases. The following is an abstract of that portion of Professor Meidinger's paper relating to production of *cold by solution:*

Heat is absorbed by bringing solids to the liquid condition; and the cold thus produced may prove sufficient to convert water into ice.

The best known of the numerous freezing mixtures that have been hitherto described is, of course, one involving ice itself; it consists of 3 parts of ice, and 1 part of ordinary salt.

Dissolving concurrently, these two substances give a temperature of —21° C.† (the freezing point of the solution). The melting of only a part of the mixture is sufficient to produce this temperature throughout the mass; and with constant admission of heat, and stirring, the low temperature is maintained till the whole is dissolved. The freezing apparatus of confectioners is well known; a tin pot containing cream, a wooden or metallic vessel inclosing the pot, and the interval filled with ice and salt, which is frequently stirred, that the ice may not sink to the bottom. In a Paris machine, for home use, the agitation of the freezing mixture is maintained by rotation of the double cylinder containing it and the cream vessel, round an axis at right angles to the cylinder's length. Prof. Meidinger has constructed a machine based on the observation that a solution of ordinary salt under 0° also fuses ice, and, so long as its concentration is maintained, produces the same low temperature as the mixture of salt and ice. He provides a sieve-like vessel, containing salt, to maintain the con-

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* From *English Mechanic and World of Science*, December 31st, 1875.

† All the quantities of heat, weight, etc., in this article, are in French measures.

centration as the ice melts. The lowering of temperature is uniform throughout the vessel, and no stirring is required. The machine has come largely into use in perfumery.

On the basis of his own experiments, Professor Meidinger has formed a table showing the respective merits of various freezing mixtures. The following extract contains the most serviceable :—

Mixture.	Decrease of Temperature.	Specific heat of the solution.	Volume weight of the solution.	Loss of heat units.		To use for 120 c.		
				1 k. Mixture.	1 l. Mixture.	Salt k.	Water k.	Cost in Marks.
1 ordinary salt, 3 ice	21°	0·83	1·18	125	100	0·5	1·5	0·34to0·12
3 cryst. Glauber salt, 2 concentrated muriatic acid	37°	0·74	1·31	55	74	2·7	1 8	1·0 to 0·6
2 nitrate of ammonia, 1 sal-ammoniac, 3 water	30°	0·70	1·20	42	51	3·	3·	7·6 to 6·8
3 sal-ammoniac, 2 saltpetre, 10 water	26°	0·76	1·15	40	46	2·1	4·2	2·6 to 2·2
3 sal-ammoniac, 2 saltpetre, 4 cryst. Glauber salt, 9 water.	32°	0·72	1·22	50	61	2·5	2·5	1·8 to 1·6

Salt mixtures give much greater lowering of temperature than simple salts, as they dissolve in much less water. Thus, 1 part sal-ammoniac is dissolved in three parts water, and lowers the temperature about 19° ; saltpetre dissolves in 6 parts water, and lowers the temperature about 11°. (Compare the fourth and fifth on the list.) It will be seen that the salt-ice mixture proves considerably more energetic and cheaper than any of the others so far as use of the materials only once is concerned. The second mixture, too, cannot be restored : nor can the last, easily, on account of the crystallized Glauber salt. Both are comparatively cheap, however. The mixture in which, by vaporization of the solution, the salt is easily renewed in its original condition, nitrate of ammonia, and sal-ammoniac is so costly at the first, that it would not do to use it only once. This was the mixture employed in an apparatus first exhibited by M. Charles at the Paris Exhibition in 1867. The tin vessel containing the substance to be frozen is inclosed in a large wooden vessel containing the freezing mixture, and is furnished with screw wings, which stir the

Table showing the Results of Experiments with the Steam Machinery of the U. S. Revenue Steamer "Gallatin," made at the U. S. Navy Yard, Boston, Mass., in the months of December, 1874, and January, 1875, by a joint board of U. S. Naval and U. S. Revenue Marine Engineers. (To accompany Report of Chief Engineer Chas. H. Loring, U. S. N., senior member representing U. S. Navy Department, and Chas. E. Emery, Consulting Engineer, senior member representing U. S. Treasury Department.)

		APPROXIMATE STEAM PRESSURE, Lbs.		12 1-2					
		MANNER IN WHICH ENGINE WAS OPERATED.		STEAM JACKET NOT IN USE.		STEAM JACKET IN USE.		STEAM JACKET IN USE SUPPLIED WITH 70 LBS. PRESSURE.	
1	DESIGNATION OF RUNS.	Number for reference	1	1	2	3	4	5	6
2		Designation in log	2	HH	GG	FF	EE	DD	CC3
3	TIME.	Date of experiment	3	December 27th.	December 27th.	December 28th.	December 27th.	January 1st, '75.	January 1st, '75.
4		Duration of experiment ... hours.	4	1.9166	2.250	2.100	2.1333	2.2166	2.200
5	STEAM, CUT-OFF, EXPANSION.	Average steam pressure in boiler above atmosphere ... lbs.	5	14.56	12.83	15.42	13.11	13.39	13.86
6		Cut-off in fractions of stroke	6	.4630	.64015	.4680	.61795	.52512	.62556
7		Ratio of expansion	7	2.01529	1.50865	1.99641	1.49316	1.80347	1.54151
8	VACUUM AND BAROMETER.	Average vacuum in condenser ... ins.	8	25.535	25.000	25.107	24.875	26.035	25.500
9		Average barometer ... ins.	9	30.248	30.248	29.980	30.248	30.619	30.619
10		Average barometer ... lbs.	10	14.847	14.847	14.716	14.847	15.029	15.029
11	TEMPERATURES. (Fahrenheit scale.)	Air. Average temperature external air ... deg.	11	36.000	38.000	36.000	38.666	25.000	26.000
12		Average temperature engine room ... deg.	12	64.000	70.500	73.000	69.666	87.000	71.333
13		Water. Average temperature sea water ... deg.	13	35.000	35.000	35.000	36.000	32.000	32.000
14		Average temperature discharge water ... deg.	14	75.000	80.250	84.000	78.333	56.500	56.000
15		Average temperature hot well ... deg.	15	116.666	121.750	118.400	123.000	115.500	113.666
16		Average temperature feed water by tanks ... deg.	16	115.710	121.777	119.285	123.250	103.714	112.250
17	REVOLUTIONS.	Total revolutions	17	4606.	5517.	5190.	5434.	5468.	5583.
18		Average revolutions per hour	18	2403.1	2452.0	2475.71	2547.18	2466.77	2536.36
19		Average revolutions per minute	19	40.052	40.8666	41.2619	42.4531	41.1118	42.2727
20	INDICATOR DIAGRAMS.	Average initial pressure in cylinder above atmosphere ... lbs.	20	10.4821	8.8711	11.6250	9.2500	8.8750	9.9285
21		Average total initial pressure in cylinder ... lbs.	21	25.3291	23.7184	26.3410	21.0670	23.9040	[illegible]
22		Average total terminal pressure in cylinder ... lbs.	22	11.1149	13.1328	12.0285	13.7270	11.7374	[illegible]
23		Average total cushion pressure in cylinder ... lbs.	23	8.7220	9.4256	9.5910	9.5470	9.1540	[illegible]
24		Average total back pressure in cylinder ... lbs.	24	3.6690	3.7800	3.6110	3.9079	3.0230	[illegible]
25		Average vacuum at half stroke ... lbs.	25	11.7140	11.500	11.500	11.178	12.500	11.92
26		Average mean effective pressure ... lbs.	26	15.8254	16.0776	16.8217	16.7983	[illegible]	[illegible]
27		Average mean net pressure (Estimated friction pressure, 2.5 lbs.) ... lbs.	27	13.3254	13.5776	14.3217	14.2083	[illegible]	[illegible]
28		Average mean total pressure ... lbs.	28	19.4944	19.8666	20.1327	20.7062	18.9128	[illegible]
29	POWER.	Indicated horse-power (effective)	29	86.9853	90.1688	95.2544	97.8675	89.6501	102.9056
30		Net horse-power	30	73.2439	76.1478	81.0978	83.3027	75.5168	88.1020
31		Total horse-power	31	107.1520	111.4167	115.7020	121.1590	106.708	123.1590
32	WATER.	Actual. Total weight of feed-water measured ... lbs.	32	6721.81	8918.954	6715.94	7827.38	6740.12	7848.632
33		Revolutions using same	33	4600.	5510.	5236.	5417.	5445.	5519.
34		Time using same ... hours.	34	1.9141	2.2471	2.1149	2.1384	2.20734	2.18778
35		Water per hour by measurement ... lbs.	35	3511.606	3982.366	3175.474	3660.325	3053.50	3587.560
36		Total weight of water received from steam jacket, steam chest, &c ... lbs.	36			177.429	165.415	291.5	243.5
37		Proportion of total water received from steam jacket, steam chest, &c	37			.026419	.021133	.043248	.031021
38		Calc. Water per hour by terminal pressure on indicator diagrams ... lbs.	38	2228.49	2679.01	2473.8	3187.992	2410.67	2978.93
39		Proportion of total water accounted for by indicator	39	.634607	.672726	.779029	.870958	.789283	.830365
40	COAL AND REFUSE.	Total coal consumed ... lbs.	40						
41		Average coal consumed per hour ... lbs.	41						
42		Coal consumed per square foot of grate per hour ... lbs.	42						
43		Percentage of refuse from coal	43						
44		Combustible per hour ... lbs.	44						
45	PERFORMANCE OF ENGINE.	Water. Water per indicated horse-power per hour by measurement ... lbs.	45	40.3701	44.1657	33.3368	37.4008	34.0591	34.8620
46		Water per indicated horse-power per hour by indicator ... lbs.	46	25.6191	29.7114	25.9703	32.5745	26.8825	28.9182
47		Water per net horse-power per hour by measurement ... lbs.	47	47.9440	52.2978	39.1561	43.9400	40.4186	40.5816
48		Water per total horse-power per hour by measurement ... lbs.	48	32.7721	35.7421	27.4453	30.2107	28.6154	29.1289
49	PERFORMANCE OF ENGINE AND BOILER.	Coal. Coal per indicated horse-power per hour ... lbs.	49						
50		Coal per net horse-power per hour ... lbs.	50						
51		Coal per total horse-power per hour ... lbs.	51						
52		Combustible. Combustible per indicated horse-power per hour ... lbs.	52						
53		Combustible per net horse-power per hour ... lbs.	53						
54		Combustible per total horse-power per hour ... lbs.	54						
55	PERFORMANCE OF BOILER.	Coal. Water evaporated per pound of coal at observed temperature and pressure ... lbs.	55						
56		Equivalent evaporation from atmospheric pressure and 100° ... lbs.	56						
57		Equivalent evaporation from atmospheric pressure and 212° ... lbs.	57						
58		Combustible. Water evaporated per pound of combustible at observed temp. and pressure ... lbs.	58						
59		Equivalent evaporation from atmospheric pressure and 100° ... lbs.	59						
60		Equivalent evaporation from atmospheric pressure and 212° ... lbs.	60						
61	CALCULATED MAXIMUM PERFORMANCES BASED ON THE WATER ACTUALLY USED IN THE DIFFERENT ENGINES, BUT CALCULATED FOR BOILERS OF DIFFERENT PROPORTIONS USING DIFFERENT KINDS OF FUEL.	Coal per indicated horse-power per hour with boilers proportioned to evaporate *nine* pounds of water per pound of coal at pressure and temperature actually used, (probably the maximum which can be obtained at sea burning anthracite coal) ... lbs.	61						
62		Coal per indicated horse-power per hour, using slow combustion in best land boilers or best Welsh coal in marine boilers, so proportioned that there will be evaporated *ten* pounds of water per pound of coal at pressure and temperature actually employed ... lbs.	62						

CHAS. H. LORING,
Chief Engineer, U. S. N.
CHAS. E. EMERY,
Consulting Engineer, U. S. R. M.

October, 1875.

Summary of Results of Experiments made with the Steam Machinery of the U. S. Revenue Steamers "Rush," "Dexter," "Dallas," and "Gallatin," at the U. S. Navy Yard, Boston, Mass., under the general direction of Chief Engineer Chas. H. Loring, U. S. N., representing the [illegible] Department, and Consulting Engineer Chas. E. Emery, representing the U. S. Treasury Department, in the years 1874 and 1875.

(To accompany detailed Report of Experiments with "Gallatin." For detailed results of experiments with the other steamers see official report dated October, 1874.)

1	2	3	4	5	6	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
NAME OF STEAMER.	TYPE OF ENGINE.	DIMENSIONS OF CYLINDERS.	APPROXIMATE STEAM PRESSURE.	MANNER IN WHICH ENGINE WAS OPERATED.	DESIGNATION OF EXPERIMENTS. No. of Series.	DESIGNATION OF EXPERIMENTS. No. of Experiments.	AVER. STEAM PRESSURE IN BOILERS.	AVERAGE VACUUM IN CONDENSER.	AVERAGE CUT-OFF IN FRACTIONS OF STROKE.	RATIO OF EXPANSION.	DURATION OF EXPERIMENTS.	AVERAGE REVOLUTIONS PER MINUTE.	AVERAGE MEAN EFFECTIVE PRESSURE IN CYLINDER.	INDICATED HORSE-POWER.	WATER PER HOUR. By actual measurement.	WATER PER HOUR. Calculated from terminal pressure per Indicator Diagrams.	WATER PER HOUR. Condensed to supply the mechanical equivalent of heat for the total work.	PROPORTION OF TOTAL WATER. Accounted for by terminal pressure per Indicator Diagrams.	PROPORTION OF TOTAL WATER. Required to supply the mechanical equivalent of heat for total work.	WATER PER INDICATED HORSE-POWER PER HOUR. By measurement.	WATER PER INDICATED HORSE-POWER PER HOUR. By terminal pressure per Indicator Diagrams.	WATER PER INDICATED HORSE-POWER PER HOUR. Per indicated terminal pressure and amount condensed to supply mechanical equivalent of heat for total work.	[illegible] PER HOUR.	RELATIVE COST OF THE POWER IN FUEL.
		Inches.	Lbs.				Lbs.	Ins.			Hours.		Lbs.		Lbs.	Lbs.	Lbs.			Lbs.	Lbs.	Lbs.	Lbs.	
RUSH.	Compound. Connected at right angles. Cylinders Jacketed.	S. L. Dia. 24. 38. Str. 27. 27.	**70**	Steam Jackets in use. Weighing coal	**I**	**1**	69.1	26.5	S. .36 L. .47	6.22	55.00	70.840	S. 29.685 L. 12.725	S. 127.918 Both.266.547	4900.10	S. 4568.23 L. 3604.00	S. 349.29 L. 460.71	S. .93 L. .74	S. .07 L. .09	**18.38**	S. 17.14 L. 13.52	S. 20.18 L. 16.56	**2.16**	1.000
			40	Steam Jackets in use	**I**	**2**	36.7	26.2	S. .60 L. .53	4.03	6.00	55.475	S. 18.882 L. 12.300	S. 63.717 Both.168.652	3726.24	S. 3328.51 L. 2857.56	S. 173.56 L. 350.22	S. .89 L. .77	S. .04 L. .09	22.09	S. 19.74 L. 16.94	S. 22.84 L. 19.02	2.57	1.191
DEXTER.	Non-compound. Unjacketed.	Dia. 26. Stroke 36.	**70**	Coal weighed during run No. 5.	**I**	**3**	68.7	25.9	.18	4.46	2.92	56.497	34.439	185.872	4134.37	3018.79	543.95	.68	.12	23.86	16.23	19.15	2.86	1.297
						4	69.3	25.2	.23	3.67	1.42	64.306	37.127	228.077	5501.26	3932.24	671.22	.71	.12	24.12	17.24	20.18	2.84	1.312
						5	67.1	25.4	.25	3.49	34.50	61.064	37.538	218.972	5231.51	3576.09	641.52	.68	.12	**23.90**	16.33	19.26	**2.91**	1.300
						6	66.4	25.3	.33	2.72	.65	72.820	42.028	292.370	7108.44	5420.24	857.09	.76	.12	24.31	18.54	21.57	2.86	1.322
			40		**I**	**7**	40.6	26.1	.26	3.34	1.32	50.848	25.583	124.267	3579.15	2341.96	369.23	.65	.10	28.80	18.85	21.82	3.36	1.554
						8	39.9	26.0	.38	2.42	1.20	55.250	30.665	161.848	4653.19	3019.52	482.06	.64	.10	28.94	18.66	21.63	3.38	1.561
						9	41.9	25.5	.45	2.08	.92	60.691	33.838	196.187	6235.93	3988.28	593.25	.64	.10	31.79	20.33	23.35	3.71	1.716
DALLAS.	Non-compound. Unjacketed.	Dia. 36. Stroke 30.	**35**	Coal weighed during run No. 12.	**I**	**10**	35.4	26.1	.13	5.07	1.52	48.681	18.521	137.962	3681.74	2648.88	418.68	.72	.11	26.69	19.20	22.23	3.11	1.438
						11	35.3	26.0	.20	3.89	1.55	56.925	21.447	186.805	5036.83	3871.18	569.58	.77	.11	26.96	20.72	23.77	3.14	1.452
						12	32.0	25.2	.26	3.13	31.00	61.519	23.525	221.447	5966.83	4442.12	682.08	.74	.11	**26.94**	20.06	23.14	**3.14**	1.450
						13	33.7	25.4	.29	2.94	1.60	64.479	24.611	242.807	7017.30	5148.68	751.22	.73	.11	28.90	21.20	24.30	3.36	1.556
						14	27.4	24.8	.39	2.32	1.53	63.467	24.126	234.295	7261.54	5336.16	727.91	.73	.10	30.99	22.77	25.88	3.60	1.665
GALLATIN.	Non-compound. Jacketed.	Dia. 34.1. Stroke 30.	**12 1-2**	Steam Jacket not in use	**II**	**1**	14.6	25.5	.46	2.01	1.92	40.052	15.825	86.985	3511.61	2228.49	281.71	.63	.08	40.37	25.62	28.56	4.66	2.155
						2	12.8	25.0	.64	1.51	2.25	40.867	16.078	90.169	3982.37	2679.04	294.67	.67	.07	44.17	29.71	32.98	5.09	2.356
				Steam Jacket in use		**3**	15.4	25.1	.47	2.00	2.10	41.262	16.822	95.254	3175.47	2473.80	305.05	.78	.10	33.34	25.97	29.17	3.85	1.780
						4	13.1	24.9	.65	1.49	2.13	42.453	16.798	97.807	3660.33	3187.99	321.02	.87	.09	37.40	32.57	35.86	4.31	1.995
				Steam Jacket in use and supplied with steam at 70 lbs. pressure		**5**	13.4	26.0	.52	1.80	2.22	41.112	15.890	89.650	3053.50	2410.07	281.22	.79	.09	34.06	26.88	30.02	3.93	1.817
						6	13.9	25.5	.63	1.54	2.20	42.273	17.738	102.903	3587.50	2978.93	326.51	.83	.09	34.86	28.95	32.12	4.02	1.861
			40	Steam Jacket not in use	**II**	**7**	44.8	25.9	.11	5.92	1.77	43.000	20.816	122.842	3194.61	2198.09	373.42	.69	.12	26.01	17.89	20.98	3.04	1.406
						8	40.9	26.1	.14	5.21	1.98	44.235	20.953	127.196	3396.75	2351.39	388.17	.69	.11	26.70	18.49	21.54	3.12	1.442
						9	43.3	25.9	.22	3.73	2.05	50.772	26.153	182.227	4373.26	3331.86	541.41	.76	.12	24.00	18.28	21.26	2.80	1.296
						10	39.4	23.6	.27	3.16	2.10	50.143	26.501	182.364	4800.24	3479.41	564.56	.72	.12	26.32	19.12	22.22	3.07	1.420
						11	39.5	25.9	.33	2.72	2.32	56.022	30.810	236.874	5800.10	4613.68	708.42	.80	.12	24.49	19.48	22.47	2.86	1.321
						12	37.7	22.7	.41	2.23	2.17	55.754	30.904	236.457	6644.76	5251.60	746.34	.79	.11	28.10	22.21	25.37	3.28	1.515
				Steam Jacket not in use—Throttled.		**13***	39.0	24.6	.69	1.41	2.57	52.682	30.356	219.465	6493.41	5729.68	650.97	.88	.10	29.59	26.11	29.07	3.45	1.596
				Steam Jacket in use		**14**	45.4	26.1	.10	6.08	2.02	44.322	19.905	121.072	2778.06	2167.33	376.20	.78	.13	22.94	17.90	21.01	2.68	1.240
						15	42.8	26.5	.14	5.07	2.05	46.057	21.699	137.501	3294.59	2363.43	415.68	.72	.13	24.02	17.23	20.26	2.81	1.298
						16	41.6	25.6	.15	4.82	2.20	45.876	21.673	136.448	3054.94	2372.37	415.08	.78	.14	22.39	17.39	20.43	2.61	1.209
						17	43.9	26.6	.17	4.49	2.22	50.308	23.646	163.251	4055.09	2846.41	499.21	.70	.12	24.84	17.44	20.49	2.94	1.362
						18	41.3	25.8	.22	3.71	2.03	49.205	24.614	166.211	3851.57	2857.89	504.53	.74	.13	23.17	17.19	20.23	2.70	1.251
						19	40.0	24.6	.25	3.32	3.75	51.151	26.382	185.192	4761.38	3435.08	576.87	.72	.12	25.71	18.55	21.66	3.00	1.387
						20	36.2	26.4	.38	2.40	2.08	54.528	28.467	213.022	5388.20	4056.68	622.77	.75	.12	25.29	19.04	21.97	2.95	1.363
						21	37.4	24.8	.42	2.21	2.30	58.246	31.902	255.005	6763.13	5464.44	778.89	.81	.12	26.52	21.43	24.48	3.09	1.430
				Condensing without vacuum—Steam Jacket not in use		**22**	70.7	1.0	.18	4.37	2.20	46.697	26.472	169.643	5083.87	4046.48	710.90	.80	.14	29.97	23.85	28.04	3.53	[illegible]
						23	66.2	1.7	.24	3.48	2.22	51.677	28.876	204.787	6012.43	5033.63	833.26	.84	.14	29.36	24.58	28.65	3.45	1.596
				Condensing without vacuum—Steam Jacket in use		**24**	69.7	1.0	.20	4.07	2.05	49.471	27.924	189.581	4904.59	4612.61	779.93	.94	.16	25.87	22.24	26.35	3.01	1.408
						25	67.4	1.7	.24	3.52	2.12	53.236	29.044	212.190	5801.32	5014.05	861.00	.86	.15	27.34	23.63	27.69	3.21	1.486
			70	Link hauled up.—Steam Jacket and Independent Cut-off not in use	**II**	**26**	63.8	24.7	.36	2.47	1.92	61.983	35.007	297.779	7514.61	5690.00	951.84	.76	.13	25.24	19.11	22.30	2.96	1.371
				Link hauled up.—Steam Jacket in use—Using Independent Cut-off		**27**	69.6	26.0	.24	3.45	2.07	58.613	32.137	258.505	5945.78	4130.64	793.12	.69	.13	23.00	15.98	19.05	2.71	1.251
				Link hauled up.—Steam Jacket in use—Not using Independent Cut-off		**28**	59.9	25.3	.38	2.37	1.95	60.949	33.968	284.181	6873.25	5379.80	894.28	.78	.13	24.19	18.93	22.05	2.84	1.313
				Steam Jacket not in use—Draining steam-chest		**29**	69.6	25.9	.15	4.90	2.50	60.247	34.973	289.152	6286.87	4714.94	843.36	.75	.13	21.74	16.31	19.22	2.56	1.183
						30*	60.1	25.8	.20	4.01	2.05	60.179	34.732	286.843	6577.98	4983.19	854.76	.76	.13	22.93	17.37	20.35	2.69	1.245
				Steam Jacket in use—Supplied direct from boiler		**31**	71.2	25.8	.15	4.87	1.87	58.464	31.820	255.306	5993.66	3958.45	766.86	.66	.13	23.48	15.50	18.51	2.76	1.278
						32	67.0	25.4	.21	3.83	2.03	61.582	33.425	282.485	7157.32	4680.75	855.77	.65	.12	25.31	16.57	19.60	2.98	1.377
				Steam Jacket not in use—Weighing coal		**33**	61.0	25.3	.17	4.46	23.95	60.502	32.353	268.630	6541.18	4551.90	808.20	.70	.12	**24.35**	16.94	19.95	**2.86**	1.323
				Steam Jacket not in use		**34***	71.5	25.2	.07	7.78	2.18	52.351	25.763	185.090	4632.68	3238.79	574.65	.70	.12	25.03	17.50	20.60	2.95	1.362
						35	68.2	25.1	.12	5.63	2.05	56.016	30.106	231.440	5501.42	3936.97	708.82	.72	.13	23.77	17.01	20.07	2.79	1.293
						36	68.5	25.9	.15	4.94	2.02	59.868	34.028	279.570	6120.30	4576.50	828.29	.75	.14	21.89	16.37	19.33	2.57	1.191
						37*	61.1	25.8	.18	4.25	1.98	59.451	34.676	282.929	6786.40	4796.05	842.00	.71	.12	23.99	16.95	19.93	2.82	1.302
				Steam Jacket in use—Weighing coal		**38**	65.1	25.3	.17	4.50	23.98	61.537	33.351	281.649	6208.37	4698.65	838.94	.76	.14	**22.01**	16.68	19.66	**2.59**	1.198
				Steam Jacket in use		**39**	71.6	25.7	.08	7.31	2.22	51.112	28.083	196.988	4036.32	3087.52	586.14	.76	.15	20.49	15.67	18.65	2.41	1.115
						40*	71.8	25.4	.12	5.68	2.02	58.586	33.631	270.395	5572.58	4520.37	810.22	.81	.15	20.61	16.72	19.71	2.43	1.122
						41*	69.9	25.8	.15	4.98	2.12	61.212	36.455	306.238	6336.42	5051.36	906.69	.80	.14	20.69	16.88	19.84	2.43	1.126
						42*	68.2	24.9	.17	4.46	4.42	61.260	35.157	295.570	6331.15	5360.83	880.76	.85	.14	21.42	18.14	21.12	2.52	1.165
						43	67.2	25.0	.19	4.19	1.93	68.724	36.896	347.985	7475.24	5978.83	1040.80	.80	.14	21.48	17.18	20.18	2.53	1.168

* See text.

October, 1875.

CHAS. H. LORING,
Chief Engineer, U. S. N.
CHAS. E. EMERY,
Consulting Engineer, U. S. R. M.

STEAM JACKET NOT IN USE.

	Weighing coal.				
1 2	**33** WJ	**34*** W	**35** V	**36** M	**37*** U
3	December 30th.	December 24th.	December 24th.	December 23d.	December 24th.
4	23.95	2.18333	2.0500	2.0166	1.9833
5	64.05	71.50	68.21	68.50	61.08
6	.17304	.071048	.12327	.15003	.18494
7	4.46074	7.7825	5.63124	4.93665	4.24913
8	25.285	25.245	25.136	25.875	25.769
9	30.326	29.8428	29.8428	30.0705	29.8428
10	14.886	14.648	14.648	14.760	14.648
11	20.909	39.750	46.000	44.250	36.000
12	71.590	67.500	73.666	72.250	66.000
13	34.511	35.000	36.000	37.000	34.625
14	73.404	75.509	75.333	76.250	68.250
15	128.372	119.000	120.333	111.500	112.625
16	123.669	113.500	117.09	109.080	107.583
17	86941.	6858.	6890.	7244.	7075.
18	3630.1	3141.069	3360.99	3592 07	3567.22
19	60.5017	52.3512	56.9162	59 8678	59.4537
20	61.2708	68.7857	66.1428	66.9165	59.3750
21	76.1568	83.4337	89.7908	81.6766	74.0230
22	15.4103	12 4695	14.1180	15.3453	16 2313
23	14.8478	10.5766	10.5766	9.9267	10.5256
24	4.2794	4.5378	4.6605	3.8714	4 036
25	11.256	10.285	10.2850	11.500	10.872
26	32.3535	25.7627	30.1064	34.0276	34 6763
27	29.8535	23 2627	27.6064	31.5276	32.1763
28	36.6329	30.3005	34.7869	37.8999	38.7123
29	268.630	185.990	231.440	279.570	282.929
30	247.872	167.128	212 352	250.029	262.531
31	304.102	217.691	267.267	311.377	315.860
32	155413.0	10088.13	11199.35	12342.613	13469.217
33	86248.	6840.	6842	7244.	7080.
34	23.7591	2.1776	2.0357	2.0166	1.9847
35	6541.18	4632.68	5501.423	6120.304	6786.495
36					
37					
38	4551.90	3238.79	3936.97	4576.50	4796.05
39	.695883	.699119	.715626	.747758	.706714
40	21580.				
41	901.044				
42	16.3085				
43	21.6089				
44	706.339				
45	24.3501	25.0294	23.7705	21.8919	23.9862
46	16.9374	17.4985	17 0107	16.370	16.9514
47	26.3893	27.7193	29.9230	23.6277	25.8499
48	21.5056	21 2800	20.5840	19.6556	21.4855
49	3.35422				
50	3.63511				
51	2.96238				
52	2.62941				
53	2.8496				
54	2.32224				
55	7.25956				
56	7.30375				
57	8.15687				
58	9 2607				
59	9.20467				
60	10.2798				
61	2 70553				
62	2.43501				

* See text.

STEAM JACKET IN USE.

	Weighing coal.					
1 2	38 JJ	39 S	40* R	41* Q	42* JJJ	43 P
3	Dec. 28th, 29th.	December 27th.	December 27th.	December 27th.	December 28th.	December 27th.
4	23.9833	2.2166	2.0166	2.1166	4.41666	1.9333
5	65.37	71.56	71.79	69.93	68.25	67.21
6	.17108	.079811	.12162	.14818	.17298	.18871
7	4.49763	7.31451	5.68382	4.9787	4.46185	4 16621
8	25.335	25.722	25.409	25.827	24.932	25.035
9	29.974	30.248	30.248	30.243	29 980	30.248
10	14.716	14.847	14.847	14.847	14.716	14.847
11	37.755	43.000	57.500	32.500	48.555	39.500
12	69.380	70 000	65.000	43.333	66.444	75.000
13	35.977	36.000	35.500	35.000	36.000	35.000
14	72.355	66.000	77.500	65.333	75.444	75.250
15	120.454	114 000	122.000	111.333	117.888	120.000
16	119.470	115.110	117.909	113.769	120.000	121.583
17	88552.	6798	7089.	7774.	16234.	7972.
18	3692.2	3066.76	3515.21	3672.7	3675.62	4123.45
19	61.5366	51 112	58.586	61.212	61.2604	62.7241
20	63.1146	70.1250	70.4642	68.6428	66.9423	65.8928
21	77.8306	84.9720	85.3112	83.4898	81.6583	80.7398
22	15.4729	12.1387	15.5255	16.5970	16.1198	17.4898
23	12.2619	9.9304	10.5256	10.5256	12 2619	10.5256
24	3.9822	3.6067	4.2397	4 0002	4.1530	4.3830
25	11.330	11.250	11.071	11.071	11.330	11.071
26	33.3510	28.0831	33.6306	36.4546	35.1573	36.8965
27	30.8510	25.5831	31.1306	33.9546	32.6573	34.3965
28	37.3332	31.6838	37.8703	40.4548	39.3103	41 2795
29	281.649	196.988	270 395	305.238	295.570	347.985
30	260.536	179.452	250.295	285 236	274.552	324.406
31	315.278	222.245	304.483	339.841	330.484	389.322
32	148863.4	8951.640	11196.82	13450.04	27978.09	14542.00
33	88531.	6809.	7063.	7796.	16243.	8022.
34	23.9778	2.2202	2.0092	2.12266	4.419115	1.94546
35	6208.37	4036.325	5572.583	6336.418	6331.153	7475.245
36	52.35	459.847	407.668	384.342	934.771	453.077
37	.034645	.051313	.036409	.028575	.033411	.03155
38	4698.65	3087.52	4520.37	5051.36	5360.83	5978.83
39	.756824	.764932	.811180	.797195	.846738	.799810
40	20230.					
41	845.587					
42	15.3047					
43	21.6089					
44	662.865					
45	22.0429	20.4901	20.609	20.6912	21.4201	21.4815
46	16.6826	15.6736	16.7176	16.8791	18.1372	17.1813
47	23.8292	22.4925	22.264	22.2146	23.0599	23.0429
48	19.6917	18 1615	18.3017	18.6452	19.1572	19.2007
49	3.00227					
50	3.24556					
51	2.68203					
52	2.35351					
53	2.54423					
54	2.10247					
55	7.342085					
56	7.41792					
57	8.28438					
58	9.36597					
59	9.46271					
60	10.56802					
61	2.4492					
62	2.20429					

* See text.

CONDENSING, WITHOUT VACUUM.

	Steam Jacket not in use.		Steam Jacket in use	
1	22	23	24	25
2	Y	X′	AA	Z′
3	December 26th.	December 28th.	December 27th.	December 28th.
4	2.2000	2.21666	2.05	2.1166
5	70.71	66.21	69.67	67.42
6	.17799	.24041	.19589	.2365
7	4 3702	3.47969	4.07141	3.52467
8	1.0000	1.708	1.000	1.729
9	30.2852	29.980	30.248	29.980
10	14.8660	14.716	14.847	14 716
11	45.000	39.500	40.428	36.000
12	77.333	78.000	74.428	74.625
13	37.000	34.000		
14				
15				
16	121.727	133.38	126.80	134.416
17	6164.	6873.	6085.	6761.
18	2801.82	3100.60	2968.29	3194.17
19	46.697	51.6767	49.4715	5323.62
20	68.8571	64.3964	67.750	64.125
21	83.7237	79.1124	82.5970	78.8410
22	19.2951	21.5017	19.6803	21 0910
23	41.2594	41.8231	44.6386	45.9243
24	14.8660	14.7160	14.8470	14.7160
25				
26	26.4717	28.8763	27.9237	29.0437
27	23.9717	26.3763	25.4237	26.5437
28	41.3377	43.5923	42.7707	43.7597
29	169.6430	204.7868	189.5806	212.1905
30	153.622	187.0570	172.608	193.926
31	264.911	309.1500	290.580	319.703
32	11186.34	13381.85	10054.40	12263.12
33	6165.	6901	6085.	6752.
34	2.20036	2.2257	2.0500	2.1138
35	5083.874	6012.43	4904.592	5801.324
36			287.569	429.25
37			.028582	.035003
38	4046.48	5033.626	4612.61	5014.05
39	.795944	.837203	.940469	.864295
40				
41				
42				
43				
44				
45	29.9681	29.3594	25.8702	27.3402
46	23.8530	24.5798	22.2355	23.6300
47	33.0934	32.1422	28 4147	29.9153
48	19.1909	19.4482	16.8902	18.1460
49				
50				
51				
52				
53				
54				
55				
56				
57				
58				
59				
60				
61				
62				

	Link hauled up.			Jacket not in use, draining steam chest.		Jacket in use, supplied direct from boiler.	
	Jacket and Independent Cut-off not in use.	Jacket in use.					
		Independent Cut-off in use.	Independent Cut-off not in use.				
1 2	26 QQ	27 SS	28 RR	29 N	30* N′	31 LL	32 KK
3 4	December 31st. 1.91666	January 1st, '75. 2.06667	December 31st. 1.95000	December 23d. 2.500	December 23d. 2.0500	December 31st. 1.8666	December 31st. 2.0333
5 6 7	63.83 .3656 2.47017	69.64 .24268 3.45409	59.92 .38303 2.37427	69.56 .15139 4.90515	60.36 .2000 4.00848	71.17 .15277 4.8742	67.00 .21267 3.82617
8 9 10	24.660 30.669 15.054	26.000 30.619 15.029	25.346 30.669 15.054	25.950 30.0705 14.760	25.807 30.0705 14.760	25.841 30.669 15.054	25.357 30.669 15.054
11 12 13 14 15 16	4.000 65.000 33.000 83.000 141.000 132.64	28.333 71.666 32.600 62.666 116.333 112.25	14.333 86.000 33.000 65.666 121.333 122.307	40.400 64.400 33.600 69.000 114.200 109.600	37.555 63.333 34.000 66.000 110.555 107.230	4.000 75.600 33.400 78.800 130.000 121.090	6.625 74.000 32.500 75.000 132.000 126.000
17 18 19	7128. 3718.96 61.9826	7268. 3516.78 58.6129	7131. 3656.92 60.9487	9037. 3614.80 60.2467	7402. 2610.73 60.1789	6548. 3507.86 58.4643	7513. 3694.92 61.582
20 21 22 23 24 25 26 27 28	51.8333 66.8873 19.5540 28.2623 6.6695 10.333 35.0073 32.5073 41.6768	55.214 70.2430 15.1004 25.4575 4.9508 11.857 32.1374 29.6374 37.0882	48.5833 63.6373 18.8456 28.3040 5.9949 11.333 33.968 31.468 39.9629	67.6875 82.4475 15.6662 9.1975 3.3432 10.984 34.9726 32.4726 38.3158	58.4285 73.1885 16.6528 10.5256 4.0527 10.9840 34.7324 32.2324 38.7851	67.5833 82.6373 13.9707 16.0540 4.2353 11.583 31.8202 29.3202 36.0555	63.000 78.054 15.6968 16.9111 4.6086 11.071 33.4253 30.9253 38.4389
29 30 31	297.7790 276.513 354.511	258.5053 238.396 298.328	284.181 263.208 334.262	289.1525 208.482 316.7935	286.843 266.196 320.313	255.306 235.246 289.286	282.4847 261.356 321.432
32 33 34 35 36 37 38 39	14500.00 7176 1.92957 7514.614 .... 5690.00 .757190	12333.590 7295. 2.07434 5945.778 517.500 .041959 4130.64 .694718	13421.62 7141. 1.95273 6873.246 374.40 .027895 5379.80 .782714	15706.75 9031. 2.49834 6286.874 415.50 .026454 4714.94 .749965	13470.28 7394. 2.0477 6577.982 233.50 .017334 4983.19 .75754	11118.167 6548. 1.8666 5993.663 458.500 .040981 3958.50 .66044	14526.107 7499. 2.02954 7157.325 301.481 .020754 4680.753 .653970
40 41 42 43 44	....	....	....	....	....	....	....
45 46 47 48	25.2355 19.1080 27.1763 21.1971	23.0006 15.9790 24.9408 19.9303	24.1914 18.9350 26.1134 20.5624	21.7424 16.3060 23.4163 19.8453	22.9324 17.3722 24.7110 20.5361	23.4765 15.5046 25.4782 20.7188	25.3370 16.5694 27.3853 22.2670
49 50 51 52 53 54	....	....	....	....	....	....	....
55 56 57 58 59 60	....	....	....	....	....	....	....
61	....	....	....	....	....	....	....
62	....	....	....	....	....	....	....

* See text.

Steam Jacket in use.

1	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
2	A	M M	B	N N	C	D	E	F
3	December 21st.	December 31st.	December 22d.	December 31st.	December 22d.	December 22d.	December 22d.	December 22d.
4	2.0166	2.0500	2.200	2.21666	2.0333	3.7500	2.0833	2.300
5	45.42	42,79	41.64	43.89	41.33	40.00	36.18	37.40
6	.10545	.1443	.15525	.1716	.22105	.25473	.3775	.41561
7	6.0785	5.0706	4.81955	4.48778	3.71444	3.32423	2.40387	2.2136
8	26.125	26.535	25.6428	26.555	25.8125	24.588	26.363	24.766
9	30.1628	30.669	30.1427	30.669	30.1427	30.1427	30.1427	30.1427
10	14.806	15.054	14.796	15.054	14.796	14.796	14.796	14.796
11	19.6666	13.333	19.000	13.000	22.000	30.800	40.857	41.000
12	69.500	80.000	74.000	75.500	76.500	69.866	65.857	72.333
13	34.416	33.000	35.000	33.000	34.666	36.200	34.000	34.000
14	61.666	60.666	77.000	61.500	80.000	96.666	74.428	85.000
15	98.333	112.000	109.571	115.500	115.000	129.400	111.143	130.33
16	102.500	109.714	106.857	110.22	113.750	123.647	105.818	123.466
17	5363.	5665.	6064.	6691.	6003.	11509.	6816.	8038.
18	2659.34	2763.42	2752.64	3018.49	2952.29	3069.07	3271.68	3494.78
19	44.3223	46.0569	45.876	50.3083	49.2049	51.1511	54.528	58.246
20	43.2083	38.875	39.82142	39.6428	39.9166	37.6153	34.4642	35.5714
21	58.0143	53.9290	54.6174	54.6968	54.7126	52.4113	49.2602	50.3674
22	9.7644	10.4290	10.3332	11.5183	11.6710	13.5460	14.7960	18.8674
23	8.4727	11.4290	8.6532	12.1612	9.7541	11.4307	14.7960	10.5818
24	3.7258	3.370	3.4664	3.8236	3.7553	4.6609	2.8686	4.5063
25	11.333	11.0830	11.6428	12.000	11.500	10.6530	11.500	10.785
26	19.9048	21.6990	21.6730	23.6458	24.6144	26.3818	28.4668	31.9018
27	17.4048	19.1990	19.1730	21.1458	22.1144	23.8818	25.9668	29.4018
28	23.6306	25.0690	25.1394	27.4694	28.3697	31.0427	31.3354	36.4081
29	121.0725	137.5010	136.4482	163.2515	166.2111	185.1921	213.0218	255.0051
30	105.866	121.350	120.700	145.992	149.331	167.543	194.314	235.022
31	143.735	158.452	158.273	189.650	191.570	217.9114	234.488	291.026
32	5618.10	6731.267	6735.70	8974.02	7845.87	17899.316	11228.702	15653.891
33	5378.	5646.	6069.	6680.	6014.	11531.	6818.	8089.
34	2.0223	2.04312	2.20486	2.21302	2.03702	3.75717	2.08394	2.31459
35	2778.064	3294.595	3054.937	4055.09	3851.567	4761.384	5388.198	6763.129
36	516.214	427.766	320.961	416.000	331.653	552.925	300.000	289.82
37	.091884	.063549	.047652	.046356	.0422583	.030908	.026717	.018514
38	2167.33	2363.43	2372.375	2846.41	2857.89	3435.083	4056.68	5464.44
39	.78016	.717365	.776570	.701933	.742006	.721446	.752882	.807975
40	....	....	....	....	....	....	....	....
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42	....	....	....	....	....	....	....	....
43	....	....	....	....	....	....	....	....
44	....	....	....	....	....	....	....	....
45	22.9454	24.0218	22.3890	24.8396	23.1727	25.7104	25.2941	26.5215
46	17.9011	17.2324	17.3866	17.4357	17.1943	18.5485	19.0435	21.4287
47	26.2413	27.1496	25.3082	27.7762	25.7922	28.4017	27.7294	28.7766
48	19.3277	20.8211	19.3017	21.3820	20.1052	21.8501	22.9786	23,2389
49	....	....	....	....	....	....	....	....
50	....	....	....	....	....	....	....	....
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52	....	....	....	....	....	....	....	....
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JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXXI. MARCH, 1876. No. 3.

EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors, the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Commissions.—The perversion of the original meaning of the word commission, from authority or power to do something, to that of the reward or payment of a fee to the commissioner, is sufficient to indicate the departure from honest dealing, which has grown up with the delegation of the right to purchase in behalf of others. That a man's ability as a broker or trader or as a professional man, may properly be measured and remunerated by some definite amount, in proportion to the value of his *commission* (in the correct and original meaning of the word) is unquestionable; and a customary, or agreed upon, poundage or percentage is one of the admitted conditions of commerce and of art; but the *private* receipt or payment of such poundage or percentage, however frequently or generally accepted, will not be *justified* by custom, as it is unwarranted by agreement of the person, company or governmental body, that incurs the expenditure.

Still it is well known that the habit exists. The increase of larger manufacturing establishments; the aggregation of capital in manufacturing and railway companies, the expenditures of cities and towns for public improvements, and of government for the same, in time of peace, and of the latter for warlike purposes, in time of war or threatening; all require the large outlay of money, generally to be entrusted to officials, under salaries for the very purpose of making the outlay; the making of such outlay being rarely, in this country at least, under the direction of brokers or professional men, with understood rates in lieu of stipends. The demand on the receipt of a *commission* under these circumstances becomes an act of dishonesty, and its payment by the merchant, tradesman, manufacturer, engineer or builder, a participation in the wrong; while the whole community *may* be arraigned for connivance in the frauds.

This condition of things is not peculiar to this country alone. One of the last numbers of the *Builder* (London) contains a statement that at a meeting of the Institute of Architects, a circular or advertising pamphlet was distributed, relating to some of the requirements of house building, in which was placed a separate notice that a commission would be allowed to architects recommending or procuring the use of the article advertised. Attention was called to the fact, and it was animadverted upon without stint or apology; but the existence of such a proposition, the reluctance to expose the name of the person making it (with an evident compassion for his ignorance, rather than an indignation at his criminality), and the neglect to pursue the subject beyond a disclaimance, leaves a grave suspicion that there may have been instances of acceptance of, and possibly of demand for, commissions, by clerks of works, if not by architects.

It is not too much to assert that both here and in England (supposing that courtesy will permit us to assert ourselves first in the order of demerit) there is a popular belief that money is made in this way by higher professional men, as well as by subordinates. It is hard to perceive how some men can live otherwise, and harder yet to comprehend how some work or material is recommended or passed except by some direct interest in the sale or in the final acceptance. The evil permeates all official and business relations, reaching to the limit of all trust or employment. It would be easy here to descant upon the relation of the unpaid or underpaid members of any mu-

nicipal, state, or of the general government, to elected or appointed officials, or the the work to be performed under the direction of such officers; or to dilate upon the opportunities for profit, of unpaid directors in companies through employees, or in whatever other ways personal emolument can be attained; but it is sufficient to restrict the present remarks to the proper relationship of advising and purchasing agents to manufacturers and dealers, in regard to *compensations.*

As a matter of pure business, it is at once admitted that a judicious purchase is of great advantage to any buyer, and that the ability, knowledge or intelligence, which enables one man to effect such a purchase better than another, is a valuable commodity to be paid for. It has come, or is coming to be recognized, that the lowest bidder method of purchase, inevitably fails to secure a satisfactory bargain. The keen purchaser who attempts to get more for a dollar than a dollar's worth, is frequently, and always in the end, outwitted—the covenants to perform become the less effectual as they are made the more binding—the more cunning the stipulation, the more knavish the contractor;—and sooner or later, such a buyer finds that he had better have made his purchase in open market, from those who would have gained a profit from the sale and have had a stake in the perpetuation of their trade or manufacture.

On the other hand the seller finds it for his interest to push his wares, and in so doing he can or will concede a brokerage, consoling himself with the idea that such a "commission" is not illegal or immoral. In this view he is unquestionably justifiable—with a qualification—that the transaction must not be a private one. The seller, however, has no right to pay for the procurement of an order, or for the acceptance of material or work, any sum of money, which will not be publicly acknowledged and openly paid. Such a payment can only be a bribe to the recipient, and a theft from the principal in the purchase.

As to the engineer or architect, the purchasing agent of whatever degree, the demand for an acceptance of such private fees cannot be characterized by too strong language, or condemned in too open a manner. If professional advisers will take the most decided stand upon these points and make public every offer for *commissions* they may receive, there will ensue a restoration of popular opinion in their behalf, and, sooner or later, a higher appreciation of the value of technical direction and advice will result.

Circular Ironclads.—The many good qualities developed on the trial trip of the circular ironclad Novgorod, designed for the Russian navy by Admiral Popoff, has brought forward several claimants for the honor of having first suggested this form of war vessel, and an animated controversy has resulted, and much light has been thrown on the efforts of others in this direction.

It is claimed that Mr. Geo. Herbert, in 1854, made designs for circular ironclad forts, provided with propelling power, which were laid before the authorities in England as early as 1855; that Mr. Geo. Rennie read a paper at the meeting of the British Association in 1858 on the "construction of fixed and floating batteries for coast defense," and exhibited models of circular ironclads.

Sir Samuel Baker claims to have submitted to the admiralty as early as 1866, plans for circular ironclads; and the firm of John Elder & Co., Glasgow, claim that the late Mr. John Elder, in May, 1868, read a paper before the Royal United Service Institution, entitled, "circular ships of war with immersed motive power," in which he advocated the building of circular ironclads, and claimed for his designs both high speed and steadiness at sea. The friends of Mr. Elder are very emphatic in the support of his claims, and hold in substance that the "Popoffkas" being circular ironclads, they cannot allow it to be understood that Admiral Popoff is the inventor; and further that in the autumn of 1868, Admiral Popoff spent some time in Glasgow, and during the greater part of two days, Mr. Elder explained to him his plans for circular ironclads.

In opposition to these statements we have that of Admiral Popoff, that he "never heard from him (Elder) anything about his spherical ship, which, in the only form in which I understood it, was impracticable, involving great draught of water and great expense," and adds, "it is my duty to say that my ship is not in any degree derived from his spherical vessel."

A comparison of the two plans shows that of Mr. Elder to have been a "small segment of a sphere," while on the other hand, in that of Admiral Popoff, the immersed portion is almost cylindrical, the bottom being flat and nearly as large as the section at the water line. It is this radical difference in design, although both are circular in horizontal section, which enables the latter to carry a much heavier armor in small draught of water, and to be built at moderate cost.

He attributes the origin of his ironclad to having been taught many years ago by Mr. E. J. Reed, C.B., that by shortening the ship the

extent of surface to be protected by armor is diminished, and by increasing the breadth the displacement is increased, and consequently the ability to carry the armor is also increased. K.

Ile's Differential Compass.—At the meeting of the Institute in December last a model of the working parts of this instrument was exhibited and explained. This compass is intended to show on shipboard any aberration of the steering needle caused by iron, either as used in the construction of the vessel or carried as cargo, and to enable a mariner to restore true reading by making due compensation.

Its principal difference from the ordinary ship's compass consists in its having two needles suspended in the usual way and placed one above the other at such distances as to preclude undue mutual influences. These needles are constructed of strips of non-magnetic material—preferably alluminum—6 in. long by $\frac{3}{4}$ in. wide. On the upper one are fastened a large number of minute steel magnets, about $\frac{3}{4}$ in. long, placed parallel with the body of the needle and the like poles all in one direction. As each magnet tends North and South, the whole needle will point in that direction.

The lower needle is composed of a strip and magnets of the same materials and dimensions, but the magnets are fastened to the strip crosswise with the like poles all in one direction, and as all these magnets tend North and South, this needle will point East and West. The needles are thus constructed in order to distribute the magnetic force evenly through their length and thus cause them to be equally influenced in aberration and compensation.

It is evident that if there be no local attraction, the two needles must stand at right angles to each other, but when such local attraction does exist, it will be detected by the inclination of the needles toward it at an acute angle; the amount of deflection of each needle depending on the position and strength of the local attraction.

Compensation to restore true reading is effected by using the repellant pole of a large bar magnet in either acute angle until 90° is restored. But as the compensator can restore 90° when placed on any line, and as it only gives true results when its direction coincides with the direction of the disturbing cause, the latter is determined by using the bar magnet in connection with a short table to be constructed at the factory and to accompany each compass. When the position of the bar magnet for obtaining true compensation has been determined, it is fixed there until there is a marked change in the ship's heading, when it will need to be determined anew.

The American Society of Engineers and the Centennial Exhibition.—It having been determined by this Society to make an exposition of the progress of engineering at the approaching Exhibition, a committee of members was delegated, with authority for this purpose. This committee, consisting of Messrs. Theo. E. Ellis, chairman, J. James R. Croes, Robt. Briggs, Octave Chanute, Alex. L. Holley, W. Sooy Smith, and William P. Shinn, have divided the labors into several heads, embracing all the branches of the profession. These several sub committees have issued circulars asking the assistance of all persons who can supply it in their respective ways; the following from Sub-Committee XI will speak for itself. Any reader of this article will please consider the communication addressed to himself:

"Sir:—The Commission, under whose direction the American Society of Civil Engineers has placed the exposition of the growth, progress and present condition of Engineering in America, at the approaching Centennial Exposition in Philadelphia, has delegated to this Sub-Committee (undersigned), the charge and arrangement of that portion of the Exhibition which relates to Steam Engineering.

This exhibition on the part of the Society is not supposed to trench upon the mechanical department of engines, boilers or models in the Hall, but to supplement and illustrate that department in its general relation to civil engineering, both historically and practically. The application of steam in internal navigation of rivers and canals, in ocean navigation, in locomotion, in construction, dredging, excavating, hoisting, water works and mines; the origin, steps of progress and final point of development of all these, afford great scope for illustration by models, copies of old or new drawings, and by descriptions. Already the possibility of recording much that has been done in steam engineering has passed away. Much, if not most, of the practice of the engineer in the work shop, in use to-day, has never been recorded at all, and above all, its origin has never been asserted or declared; the opportunity at this time given to perpetuate the memory of invention and of skill, must now be accepted or the history be lost. Above all, the isolated practice and individual development of the directing engineer are generally left unnoticed and undescribed. For the collection of this kind of information, and its presentation at the Centennial Exhibition in suitable manner, the Centennial Commission has placed at the disposal of the American Socie-

ty of Civil Engineers, a large room in the Main Building, of desirable location and ready access, and the Committee confidently appeals to engineers to supply the requisite material.

Upon these grounds the Sub-Committee on Steam Machinery asks you to furnish such plans, models, or descriptions as you may have or be willing to prepare.

It is especially desirable to have models of old engines, locomotives, or boilers or machinery, now superseded or improved, and it is recommended to supply photo-lithographs of drawings or tracings. It would be well to make or have made the photo-lithographs to a uniform size of sheet not over 12 x 10, with a scale drawn on each sheet.

The Sub-Committee would also ask you to communicate this request to any persons who may to your knowledge possess any engineering information desired by the Committee, and solicit their contributions.

We want descriptions and illustrations of engines, boilers and work long since gone out of use, of those in use to-day, and of those prospectively valuable. The descriptions should be concise, the statements confined to points of verification, and without allusions to rivals in former or present existence. The purpose of our exposition is to furnish to foreign and American civil engineers, historical and practical information regarding steam engineering.

For the convenience of readers, it is requested that descriptions or writings be made on legal cap or cut foolscap paper, using one side only to write upon.

Any members of the Society, or other gentlemen (to whom they shall give this circular, or from whom they may solicit contributions) are requested to communicate with the Chairman of the Sub-Committee, stating what can be contributed *or obtained*, together with memoranda of space wished for, and such other information as will ensure the proper use of material and the best place to exhibit it in.

It will confer a great favor if you will give a written answer to this letter at the earliest moment, if anything occurs to you, or if you yourself can do anything to advance the purpose of this Committee, as set forth above. Respectfully yours,

ROBERT BRIGGS,

Address, Chairman Sub-Committee XI.

Room 2, Franklin Institute Building, No. 15 South 7th Street, Philadelphia, Pa.

Correspondence.

To the Editor of the JOURNAL OF THE FRANKLIN INSTITUTE.

DEAR SIR:—In the February number of the Journal, an article on "Safety Boilers" is so worded as to lead the reader to draw an unfavorable conclusion with regard to all boilers constructed of cast iron.

The Harrison Boiler is composed wholly of the material in question, except the bolts required to hold the parts together, and we claim that perfect safety from destructive explosions, has been attained by its mode of construction, notwithstanding the fact, that the castings are exposed to the direct action of the fire.

In the article referred to, you say, "there is a possibility of attaining a *measure of safety* in the construction of boilers in small and multiplied parts." We would substitute the words *perfect safety from destructive explosions*, for measure of safety; and add that the small and multiplied parts. if of cost iron, should be, to use Mr. Harrison's own words, "of such a form as will prevent harm in case of rupture.

In answer to your objection to the use of cast iron where exposed to the fire, we would again quote Mr. Harrison's words: "Cast iron expands less at the same temperature than wrought iron, and this difference might seem likely to interfere with the tightness of the joints in the Harrison Boiler. But with the compensating curved lines of the units, and a due proportion being maintained between the bolts and the spheres, no trouble need arise from irregular expansion."

We claim, and experience has proved us correct, that by the form used for the sections of the Harrison Boiler, considerable elasticity has been secured, thereby preventing the difficulties suggested by you, and which certainly have to be guarded against in the construction of a cast iron boiler.

The best proof that it is both possible and practicable to make a boiler of cast iron, and attain safety, is the fact that, after a test of thirteen (13) years, of the great number of Harrison Boilers that have been made and are in use, there has not been a single case of destructive explosion.

In the JOURNAL OF THE INSTITUTE for February, 1867, will be found a report of the Committee on Science and the Arts, of a series of experiments, and tests of the most severe character; this report contains the following words: "The Committee are impressed with the great utility of the boiler, as one perfectly safe and free from all danger of explosion even when carelessly used. And the report closes with these words, "with the known advantages of the use of cast iron, and the unlimited scope in the arrangement of heat absorbing surface, coupled with the demonstrated fact of *safety*, your committee unhesitatingly approve, and heartily recommend it to public favor." Signed, Coleman Sellers, Chairman, John Agnew, J. F. Frazer, Henry Morton, J. C. Cresson.

In 1871 the Rumford Medal was awarded by the American Academy of Arts and Sciences, to Jos. Harrison Jr., "for his method of constructing Steam Boilers, by which *great safety* has been secured." This honor was entirely unsolicited by Mr. Harrison, and is additional proof that the safety of the boiler had become an acknowledged and undisputed fact. Yours, Respectfully,

HARRISON BOILER WORKS,

Philadelphia, Feb. 18th, 1876. per Lewis Sylvester.

The Metric System of Measures and Weights.—At the November meeting of the Boston Society of Civil Engineers, a report was made by the committee appointed to consider the introduction of the metric system and what action the society ought to take respecting it, and the following resolves and orders were adopted:

Resolved, That it is very desirable that the metric system of weights and measures should be generally adopted, and the irregular standards now in common use abandoned.

That the committee on the metric system be hereafter a standing committee.

That the standing committee prepare a memorial to the Congress of the United States on behalf of this society, praying that honorable body to enact that after some fixed date, the metric standards in the office of weights and measures at Washington should be the sole authorized public standards.

That approximate weights and measures be procured for the society rooms.

That the State Board of Education and the Boston School Committee be addressed, urging that the instruction be made more thorough by putting the real weights and measures into the hands of the pupils.

That the committee be instructed to communicate to the U. S. Commission for testing iron and steel, a request on behalf of this society, that their report may be made in terms of the metric as well as the more common standards.

That the committee be authorized to open correspondence with other societies with a view to securing united action in petitioning Congress.

That the secretary be instructed to publish what action the society has taken in this matter, in the principal newspapers and professional periodicals.

Improvement in process of melting iron in cupolas.*—At the Edgar Thompson steel works (Bessemer), at Pittsburgh, the difficulty which frequently occurs in the cupola for melting iron in continuous use, of a scaffold (or obstruction of metal and coke in form of a mass or shelf adhering to the sides of the cupola), presented itself; and the Superintendent of the works, Mr. Wm. Jones, conceived the idea of effecting the removal by the use of pulverized fuel, injected with the blast, at the tuyeres through which the air was usually forced. Upon placing a quantity of small coal in the tuyere pipes, and putting on the blast, the result was immediately successful, in the removal of the entire scaffold, and the cupola afterwards continued in work as usual. A further consideration led to the conclusion that scaffolding might be altogether prevented by a continuance of the process, and an arrangement has now been effected, whereby a portion of fine coal is infused into the blast at all times; which process has not only prevented the formation of scaffolds since, but has melted the iron so much better and more rapidly, that only one cupola is used at this time, where two were necessary before the pulverized fuel was introduced.

But this is not the only or most important advantage secured by this discovery. It is well known to the iron founder that the great waste of iron in melting in a cupola, occurs from the exposure of a mass of white-hot, or melted iron, where little or no fuel is present, to a current of air, in which the iron itself burns freely. By supplying a portion of carbon with this air, not only the requisite heat for melting the iron will be furnished, but the iron itself will be protected from oxidation. The tuyeres of the cupola at the Edgar Thompson steel works, when using the pulverized fuel, are as bright as those of a blast furnace at a temperature of 1000° Fah., and the walls of the lining are glazed.

This improvement is found not only to save the waste of iron, but to transmit to the converter a much larger proportion of the carbon originally in the pig,—a very important consideration. In conclusion, this improvement is not limited to the Bessemer process, but would be of great value to all cupolas melting iron for castings of any character, as well for the light castings of the stove moulder, where it will preserve the fluidity of the metal, and softness of the plates; and

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*Extracted from *Am. Manufacturer and Iron World*, Pittsburgh, Feb. 24th, 1876.

also for the machinery founder, where the uniformity of character from long or heavy heats is especially desirable; and it is possible that the principle may be extended to the blast furnace itself.

The Iron Industry.—The American Iron and Steel Association has just published a revised directory of furnaces, rolling mills, steel works, forges and bloomeries in every State of the Union. This is an exceedingly valuable pamphlet of 136 pages. The following summary of the number and capacity of the furnaces and rolling mills in the United States is given:

	Tons of 2240 lbs.
Whole number of completed blast furnaces January 1, 1876, ...	713.
Annual capacity of all the furnaces, .	4,856,810 tons.
Whole number of rolling mills January 1, 1876, ...	332.
Whole number of single puddling furnaces (each double furnace counting as two single ones), ...	4,475
Total annual capacity of all rolling mills in finished iron, . . .	3,740,860 tons.
Annual capacity of all the rail mills in heavy rails, . . .	1,732,410 tons.
Number of Bessemer steel works January 1, 1876, ...	11.
Annual capacity in ingots, . .	450,000 tons.
Number of Bessemer converters, . .	24.
Number of open-hearth steel works January 1, 1876, ...	16.
Number of open hearth furnaces, . .	22.
Annual capacity in ingots, . .	41,000 tons.
Number of crucible and other steel works January 1, 1876, ...	39.
Annual capacity of merchantable steel, .	97,550 tons.
Of which there are of crucible steel, .	41,000 "
Number of catalan forges making blooms direct from the ores January 1, 1876, .	39.
Annual capacity of blooms and billets,	53,080 tons.
Number of bloomeries January 1, 1876, making blooms from pig iron, . .	59.
Annual capacity in blooms, . .	53,750 tons.

Franklin Institute.

HALL OF THE INSTITUTE, Feb. 16, 1876.

The stated meeting was called to order at 8 o'clock, P. M., Vice-President Chas. S. Close, in the chair.

There were present 108 members and 7 visitors.

The minutes of the last meeting, held Jan'y 19th, were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting the following donations were made to the library :

Annual Reports upon the Preservationof the Falls of St. Anthony, Construction of Lock and Dam at Meeker's Island, Minnesota, and Improvement of Minnesota River, in charge of F. W. Farquhar, Major of Engineers, etc., being Appendix H of the Annual Report of the Chief of Engineers for 1874. Washington, 1874; also Appendix J of the Annual Report of the Chief of Engineers for 1875. Washington, 1875. From Gen. A. A. Humphreys, Chief of Engineers.

Report on the Compressive Strength, Specific Gravity, also Ratio of absorption of the building stones in the United States, by Q. A. Gilmore. New York, 1876. From D. Van Nostrand, Publisher.

Papers relating to the foreign relations of the United States, transmitted to Congress with the Annual Message of the President, December 6, 1875, preceded by a list of papers and followed by an Index of Persons and Subjects ; 2 vols. Washington, 1875. From the Dept. of State.

Laws and regulations of the American Philosophical Society, held at Philadelphia, for promoting useful knowledge, as finally amended and adopted Dec. 16, 1859. Together with the Charter of the Society and a list of its presidents. Philadelphia, 1875. From the Society.

Eighty-seventh Annual Report of the Regents of the University. Transmitted to the Legislature, February 18, 1874. Albany, 1874.

Fifty-seventh Annual Report of the Trustees of the New York State Library for the year 1874. Transmitted to the Legislature, Feb'y 5, 1875. Albany, 1875.

Twenty-sixth Annual Report on the New York State Museum of Natural History, by the Regents of the University of the State of

New York. Transmitted to the Legislature May 2, 1873. Albany, 1874. From the Board of Regents, University, N. Y.

The Actuary further reported that there were two vacancies in the Board, one arising from the election of Mr. J. E. Mitchell as vice-president, and the other from a tie vote at the annual election.

The Actuary also presented the report of the Board on the preamble and resolution relating to the increased usefulness of the Institute, referred to the Board at the December meeting, which report was adopted.

The report contained the following suggestions:

1st. To ask of *each member* of the Institute his *individual* exertions to add to the roll of membership.

2d. For the members of the Institute to give their support and encouragement to the committee on instruction by evincing more interest in the lectures given in the Institute.

3d. To encourage minors and apprentices to *make use* of the facilities for instruction afforded by the Institute, under the privilege of membership. Your committee would recommend extending the use of the library and reading room to apprentices on payment of one dollar yearly for each.

4th. That the drawing school be enlarged so as to accommodate *all* applicants.

5th. That in addition to the usual course of lectures, a second course be instituted, intended particularly for apprentices, and those who have not enjoyed the advantages of a generous education. Said second course of lectures to consist of *elementary instruction* in mechanics, pneumatics, hydrostatics, hydraulics, optics, chemistry, etc. This course of lectures to be free to all on payment of a nominal fee for admission.

6th. That a small pamphlet be published for distribution, being a guide for apprentices and young students to approved text books on the various sciences and industrial arts.

7th. That at the monthly meetings of the Institute—in addition to the exhibition of novelties, and the reading of papers—we invite observations derived from the *practical every day work* of the mechanic, artisan and scientist. Simple as some of these observations may appear, they often open up by discussion a mine of information to those not practically versed on the subject.

Mr. J. J. Weaver presented the following, which was adopted:

Resolved, That the report of the Board of Managers touching the increased usefulness of the Institute, as presented and adopted this

evening, be printed and sent to the members with the notices for the next monthly meeting.

Mr. Emil Geyelin read a paper on the "Comparative value of turbine wheels under part gate," which was illustrated by diagrams and pictures projected on the screen. Mr. Robert Briggs followed with some remarks on the construction of turbine wheels.

The Secretary presented some specimens of vulcanized fiber, to be used as packing for steam joints, and as an antifriction material in the wearing parts of machinery.

The Secretary presented a communication from the Boston Society of Civil Engineers, asking the co-operation of the Institute in petitioning Congress to fix a date after which the metric system of weights and measures, shall be the only legal standard.

On motion of Mr. W. P. Tatham the communication was referred to a committee of three for a report.

The Chair appointed as such committee, Messrs. W. P. Tatham, Coleman Sellers and Robt. Briggs.

Mr. H. W. Bartol called attention to the two vacancies in the Board of Managers, as reported by the Actuary, and nominated Messrs. Richard McCambridge and Mr. C. H. Banes, they having received the highest number of votes at the annual election, except Mr. Adamson, who had declined.

The following members were also nominated; Dr. C. M. Cresson, H. G. Morris, T. Morris Perot, Robt. Briggs.

On motion, it was resolved that the meeting do now proceed to an election of one member of the Board to fill the vacancy caused by a tie vote at the annual election, and another to fill the vacancy caused by the election of Mr. J. E. Mitchell as Vice-President, and that the one receiving the highest number of votes be considered as elected for the longer term; and the one receiving the next highest for the shorter term.

The Chair appointed Messrs. Hector Orr, C. Chabot, and J. W. Nystrom as tellers; after all had voted who wished, the tellers reported that Mr. Briggs had received the highest, and Mr. McCambridge the second highest number of votes, whereupon the Chair announced that Robt. Briggs was elected a member of the Board of Managers to serve two years and eleven months, and Richard McCambridge to serve eleven months.

The following letter from Mr. B. H. Moore was read:

Philada., February 1st, 1876.

To the President and Members of the Franklin Institute:

GENTLEMEN:—Permit me to tender to you my resignation as one of the Vice-Presidents of the Institute.

Very truly yours, B. H. MOORE.

Mr. Bullock remarked that he regretted to learn of the contemplated resignation of Mr. Moore. For many years Mr. Moore has been very active in the interests of the Institute, especially in the committees of which he was a member. We cannot afford at the present time to lose the value of his long experience. Should his resignation be accepted, he will be no longer a member of the Board of Managers. The following resolution was offered and *unanimously* adopted:

Resolved, That the consideration of Mr. Moore's resignation as Vice-President of the Institute, lie over until the next meeting, in hope that Mr. Moore will be induced to reconsider said resignation.

Mr. Orr announced the death of Prof. John C. Cresson, with some remarks on his long connection with and great service to the Institute, and offered the following preamble and resolutions, which were unanimously adopted.

WHEREAS, Since our last stated meeting we have to report the death of Professor John C. Cresson, a member of the Franklin Institute for forty-two years, and during the most of that period active as a manager; for nine years its president, and for a quarter of a century, chairman of its committees on science and the arts; therefore,

Resolved, That we hereby acknowledge by his death our loss in the various relations which he has borne among us, whose duties he discharged with faithfulness, constancy and rare suavity, even under declining health, and now that he has answered the stern summons which await us all, and in view of the close of this long service, we feel that we may not soon look upon his like again.

Resolved, further, That these proceedings be entered in full upon our minutes, and a copy of them be presented to the family of Mr. Cresson.

Mr. J. E. Mitchell, one of a committee appointed by the Board of Managers upon securing room at the Centennial Exhibition, stated that they had secured a very eligible room in the northwest portion of Machinery Hall, and have been authorized by the Board to furnish it for an office and reception room of the Franklin Institute.

On motion, the meeting then adjourned.

J. B. KNIGHT, *Secretary.*

Bibliographical Notices.

The Elements of Physical Geography, for the use of Schools, Academies and Colleges.—By Edwin J. Houston, A. M., Professor, etc., in the Central High School of Phila. Eldredge & Brother, Philadelphia, 1875. Price, $1.75.

This epitome of Physical Geography is intended as the elementary book for school children, having been condensed to include merely the necessary groundwork of the study, while at the same time it has been made to be comprehensive of all the principal facts. Great care has been taken to secure strict accuracy of statement, with such explanations as shall make clear to the mind of the student the relation of the physical conditions to themselves, and to the results of observation. Besides being well compiled and edited, the book is admirably printed, in quarto form, with clear type, upon good paper, and serviceably bound; and from comparison with similar text books, it appears to present itself to much favor with teachers and to the community.

Burley's United States Centennial Gazetteer and Guide.—S. W. Burley, Philadelphia. By Charles Holland Kidder, Editor, 1876. Price, $2.00.

This combination of the history, geography, compendium of the last census, compilation of the constitution, and other information relative to the United States; together with a Guide to the U. S. Centennial Exhibition, and cognate matter, accompanied with numerous advertisements of the greatest value to the parties advertising, is really a well collated mass of somewhat desultory information, carefully edited and neatly published. The book would be somewhat improved if the reading matter had as good an index as the advertisements; and second and succeeding editions being promised, perhaps this addition will be deemed advisable, as an inducement to the purchasers of the first, to secure the following editions. The work will undoubtedly have a large circulation.

The Economy of Workshop Manipulation.—By J. Richards. E. & F. N. Spon, London and New York, 1876.

The contents of this work have mainly been published in the Journal of the Franklin Institute, having originally appeared on its pages. The separate papers as they came out, were copied into the leading scientific journals, and educed much approbation for their practical, instructive character. The whole has been collected and reprinted in 16mo. form, suitable for the library or the student.

Without entering into any review of a book whose contents are so well known to the readers of the Journal, it is sufficient to notice the fact that it can be bought as a whole, and to recommend the purchase.

Civil and Mechanical Engineering.

STEAM BRICK KILN.

By Henry W. Adams, M. D.

(Abstract from a paper read before the Franklin Institute at the meeting, Jan. 19, '76.)

The object of this paper is to describe a new and improved process of burning a kiln of bricks, uniformly hard, without a salmon brick, or a blackened, or a glazed brick in the kiln, and in one-half the time, and with one-half the cost for fuel now required.

Bricks may be made by any of the known processes, but they are then only pieces of mud, and are not, in this condition, merchantable. They must be burned in order to be of any value. The comparative value of a brick made from our beautiful clay, depends upon its hardness and the brightness of its deep red color. To develop these qualities a high, sustained, and uniformly distributed heat is necessary. Such a heat cannot be secured in the old kilns. The outside walls absorb a large portion of heat and thus rob the bricks next to them, of the heat necessary to burn them hard. The heat, ascending from the fires, passes freely, from the top of the kiln into the air, and is largely wasted. Hence, more fuel is used to burn an old kiln than is needed, if it could be properly distributed and utilized. When the fires are first fed with coal the gases generated fill the top of the kiln more abundantly and raise the temperature of the bricks; soon the coal cokes, and the production of incandescent gases, rising through the kiln, is diminished. The superincumbent air, now no longer lifted from the top of the kiln, by the ascending gases, settles down upon, and insinuates itself between the top courses of the kiln, and cools them. Thus the top and sides of an old brick kiln produce a large quantity of salmon bricks. These bricks are worth in this market about seven dollars per thousand. They average about one-fourth part of the kiln. It costs just as

much to dig the clay, to temper it, to mould and dry these bricks, and set, and burn and handle them, as it does to make hard stretchers and paving bricks, which are worth from sixteen to twenty dollars per thousand. Besides in an old kiln, only a small number of pressed bricks can be properly burned in the heart of the kiln. The arches, from necessity, are always overburned in consequence of prolonging the firing sufficiently to burn the top and sides of the kiln into respectable salmon. This is a fair statement of the case. The practice and skill of generations have failed to remedy these defects.

To burn any kiln of bricks uniformly hard, and of a deep red color, three things, at least, are necessary :

1. The necessary quantity and degree of heat must be made.

2. This heat must be equally distributed to and surround every brick in the kiln for the same length of time.

3. This heat must be held in the kiln, under a pressure greater than the outside air, so as to cause it to fill the entire honeycomb of the kiln, and wrap every brick, and burn the top and sides as quickly as the bottom.

If these conditions can be realized in a kiln, it is easy to see that a uniform result will be obtained. But, to do this, it is necessary that the kiln should be an oven. The heat must be made outside of the kiln proper, and driven into, and under it, by forcible jets of steam, in order to fill the kiln with the necessary heat, under pressure. The top must be banked down by at least two platting courses of burned bricks to hold in the heat. In an old kiln the draft is shut off by closing up the top so tightly ; but in the new kiln, it is practicable to do so, because no dependence is placed on the natural draft.

For three or four hundred dollars an old brick kiln can be converted into one suited to the new process. Take for example a ten arch kiln, built in the old style. To alter this, take out the grate bars and widen the ash pits to the width of two feet, and turn an arch over each, composed of fire bricks, and filled with pigeon holes about two inches square, to let the heat through under the whole bottom of the kiln. The floor of the kiln is leveled off, and the bricks to be burned are set directly on this floor, without arches. The kiln is set in the usual manner, and two platting courses of burned bricks are laid down on the top platting course of green bricks. They are left loose enough to let the water smoke escape, then tightened down

when it has gone. The fire places are built in front of the old fire doors, on the outside of the kiln, and the grates in these furnaces are four feet long, and two feet wide, and are on a level with the old ash pits, so that the products of combustion are driven into the permanent and pigeon holed arches, under the bottom of the kiln. Jets of steam, escaping from nozzles, three-sixteenths of an inch in diameter, are let into the furnaces, over the fire doors, under a pressure of about sixty five pounds to the inch, sweeping over and across the burning fuel. They make a partial vacuum in the furnace next to the fire doors, and draw up large volumes of air to intensify the combustion. No smoke is left unconsumed. The white hot gases, and superheated steam are forced under the whole bottom of the kiln and made to pass up through the pigeon holed arches, and thence through the bottom of the kiln, and fill the interstitial spaces between the bricks.

The top platting courses being now closed up tight, the kiln becomes an oven, filled in every part with a uniform heat. A partition is placed in the middle of the length of each arch to prevent the two opposite blasts from acting against each other. The steam is superheated at the expense of the overheated arches and bottom of the kiln, and becomes a carrier to lift up the heat and circulate it through the upper parts of the kiln. To cheapen the cost for fuel and to produce a large volume of flame to help forward the process of burning and coloring the bricks, I surround my kiln with a half inch pipe, from which branches, one-fourth of an inch in diameter, lead and look over an inch hole through the top of each furnace, to allow a small stream of crude petroleum, about as large as a needle, to fall down on to the red hot coals and burst into flame. The jet of steam shooting over the fire door and through the furnace, draws in air and produces the most intense combustion, and supplies the entire bottom of the kiln with an abundance of heat of the highest and most uniform intensity. This great source of flame and gases enables the use of cheaper fuel and the substitution of fine instead of ordinary coal. The grates are plates of cast iron, four feet long, and two feet wide, perforated with small round holes, about three-eighths of an inch in diameter, on the upper side, and half an inch wide on the under side, to let the ashes fall through without clogging. The fires are kindled with wood and large coal at first, and then the fine coal is gradually thrown on, and kept about a foot thick. The small

stream of petroleum falling on to this red hot bed bursts into flame, and the forcible jets of steam draw in the air for perfect combustion, and nothing can exceed the economy, regularity, and perfection of the heat thus produced.

It is this perfect regularity, and continuity of the heat produced by the furnaces, which render the burning of the kiln so easy and so perfect. There is no danger from the use of petroleum in this manner. Explosions can never take place with any hydro-carbon, without an admixture with its vapor of atmospheric air, or oxygen. When stored in air-tight pipes, it is just as safe as water.

It now costs from two hundred and seventy-five to three hundred dollars to burn a kiln of two hundred thousand bricks, while in the same sized kiln by my process, every brick can be burnt, and burnt hard, for one hundred and ten dollars, or fifty-five cents per thousand.

So far as I know I am the first who ever used steam in a brick kiln, to be superheated by the excess of heat in the arches, and bottom of the kiln, and to lift up this heat and distribute it in the upper parts of the kiln. My first patent for this use of steam was dated July 21, 1868. When this patent was examined by the United States Patent Office, it was found that the word steam had never been used in connection with a brick kiln in the world. This patent was taken out in 1868, in nearly every country in Europe. In the specification of the American patent, I say: "The life of my invention consists in a new method of producing, distributing, transporting, and retaining the necessary heat in all parts of the kiln, so as neither to overburn the bottom or underburn the top, but to equalize the heat of both by means of a positive, reliable, and instantaneous power, to supply any desirable degree of heat to all parts of the kiln alike. This I accomplish by the accurate and positive manner of introducing air and steam into the fire places, the former to promote perfect combustion, and the latter to become superheated, at the expense of the overheated fire places and bottom bricks, and both to carry up caloric to be distributed and utilized in raising the topmost courses to a settling heat."

Another of my patents was dated July 20, 1869, and covered some additional details, such as the building of the fire places outside of a brick kiln, and the forcing of the products of combustion into the kiln by jets of steam. Amongst the claims was one allowed in this patent for the use of steam, and is in these words: "The arrange-

ment of furnaces in a brick kiln, with jets of steam discharging into the furnaces, substantially as and for the purpose set forth." These patents were parted with soon after they were issued, but the parties holding the right so modified the disposition of the fires and introduction of the jets, that their kilns never worked satisfactorily, and the patent was generally regarded as a failure. Had the kiln been arranged as patented, with an upright draft, its success would have been perfect at the start. The control of the original patents has now reverted to me, and with a new patent, dated Nov. 23, 1875, there is secured every useful detail which experience has shown necessary to make the invention all that can be desired.

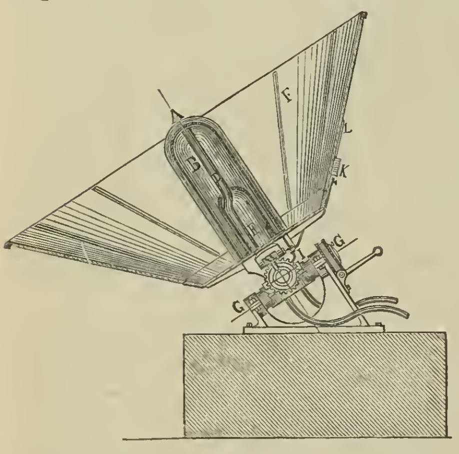
To show that these statements are supported by actual accomplishments, I will state that four kilns have been burned off this last fall, for this time with the upright draft, in accordance with the patents. These were small kilns, and were built at the Fish House Station, near Camden, by Mr. Richard D. Cox, on the yard of Mr. Reeves. All four of these kilns were burned in half the ordinary time, and every brick was perfectly hard. The last kiln is now standing for exhibition, full of bricks, just as burned off. There is not a brick in this kiln, including the top platting courses, but what is hard stretcher. It settled thirteen inches, and was burned in just forty-nine hours by a man who never burned a kiln of bricks in his life.

A further corroboration of these statements will be found in the fact that Profs. J. P. Cooke, Jr., and E. N. Horsford, of Harvard University, examined and reported favorably on the operation of the process, while the Mass. Brick Co., of Cambridge, near Boston, have put the kilns into operation with great success. When we consider that one thousand of bricks is required, to each seven or eight inhabitants of our cities per year, and that over $1.00 per thousand in price, and $1.00 per thousand in quality, is saved by the new kilns, the magnitude and the value of this improvement is made comprehensible to the minds of all.

Asphalt Pavement in England.—Much dissatisfaction has arisen from the use of this pavement in the crowded thoroughfares of London. The constant falling of horses and of men upon the smooth surface, made slippery by the thin layer of slime which the damp climate produces from street offal, has reached a point beyond the endurance of the English public. It is proposed to substitute wood pavement.

MOUCHOT'S SOLAR BOILER.*

We reproduce from our contemporary, *La Revue Industrielle*, the following illustration, and a description of an interesting apparatus constructed by M. Mouchot, Professor at the Lycée of Tours. This apparatus is, in fact, a solar boiler, and the letters upon the section refer to the following parts: A is a glass bell, B is a boiler with a double envelope, D is a steam pipe, E is a feed pipe, F is a conical silvered mirror; G G is a spindle, around which a motion is given to the machine from east to west; H is the gearing regulating the inclination of the apparatus on the spindle G G, according to the seasons; I is a safety valve; K is a pressure gauge, and L is a water gauge.



The construction of an apparatus intended to utilize the heat of the sun's rays depends on a more or less perfect knowledge of: 1. The amount of heat produced in a given time on a given surface by solar radiation. 2. The power of reflection and absorption of the different substances to be employed. According to Pouillet, if the atmosphere did not exist, there would fall per minute, on each square centimeter of the great circle forming the base of the hemisphere lighted by the sun, a quantity of heat represented by the number 1·7633, taking as a unit the amount of heat required to raise one gram of water from 0 deg. to 1 deg. In passing through the atmosphere from 21 to 28 per cent. of the heat is absorbed, even in fine weather. Forbes and Kaemtz, at the end of long investigations, arrived at the conclusion that the amount of heat which reaches the earth in this climate, is not so great as that named by Pouillet. On the other hand, the experiments of Sir John Herschel, at the Cape of Good Hope, led him to think that the solar heat, striking vertically, gave considerably less heat than was as-

* From *Engineering*, London, December 31st, 1875.

signed at Paris by Pouillet. Probably if the amount of 10 calories be taken for this climate, it will be within the mark. The investigation of Melloni demonstrated that the quantities of radiant heat transmitted by a sheet of glass, diminishes as the thickness of the glass increases. If a smoked metal plate be placed under a glass bell, the luminous rays will heat the metal, but the rays reflected from the plate will not pass through the glass; the black coating possesses to a high degree the faculty of absorbing the heat and light rays. Moreover, it resulted from the studies of MM. La Provostage and Desains, that silver is the best reflector of solar heat, and that a silvered mirror reflects about 92 per cent. of the whole. From the preceding data it appears to follow that in the construction of the solar boiler the apparatus should be placed under a glass casing, and silvered mirrors would be preferred for the concentration of the solar rays. The parabolic cylinder, and the regular truncated cone, produced by the rotation of an isosceles triangle, seem to be the best forms to adopt. These conditions have been carried out in the apparatus of M. Mouchot. It is composed of three distinct parts, the metallic mirror, the blackened boiler, the axis of which coincides with that of the mirror, and a glass envelope permitting the sun's rays to reach the boiler, but preventing their return. The ratio of the heat utilized with the surface thus isolated, increases with the extent of this surface. The mirror has the form of a truncated cone, with parallel bases, and the generating line makes an angle of 45 deg. with the axis of the cone. This is the best form that can be adopted, because the incident rays striking parallel to the axis, are reflected normally to this axis, and give a heat area of maximum intensity for a given opening of mirror. The reflectors are formed of 12 silvered sectors, carried by an iron frame, in grooves of which they slide. The diameter of opening is 112·3 in. at the top, and 39·3 in. at the bottom, giving an effective mirror area of about 45 square feet. The bottom of the mirror is formed of a cast iron disc to add weight to the apparatus. In the centre of this disc is placed the boiler, the height of which is equal to that of the mirror. It is of copper, blackened on the outside, and is formed of two concentric bell-shaped envelopes, connected at their base by a wrought iron ring The larger envelope is 31·5 in. high, and the smaller 19·68 in.; their respective diameters are 11·02 in. and 8·66 in. The water is introduced between these two envelopes, so that it forms a cylinder 1·18 in. thick.

The amount of water does not exceed 4·4 gallons, and about one-third of the annular space is left as a steam chamber and connected with the motor by a flexible tube. At the foot of the boiler is placed the feed water tube. The glass envelope or bell is 15·75 in. in diameter, and 33·46 in. high, the thickness of the glass being ·2 in. thick. A space of nearly 2 in. is thus left between the sides of the glass and the copper envelope.

Thus arranged, the apparatus is mounted on an inclined axis, the angle of which can be made to change to correspond with the motion of the sun, and a rotating movement of 15 deg. per hour can also be given to it. To effect this double object, the apparatus is carried on trunions resting on a shaft perpendicular to their axis, and this shaft forms, from north to south with the horizon, an angle corresponding to the latitude of the place. Two movements result from this arrangement which permit the apparatus to follow the course of the sun, since by a half revolution it turns from sunrise to sunset, whilst by an annual rotation of 46 deg. at most, on the trunions, it is brought opposite the sun in all positions. This double movement is effected by means of worm gearing, the first being repeated at half hour intervals, the second every eight days.

Experiments made with this apparatus at Tours showed that in 40 minutes, 44 lbs. of water were raised from a temperature of 68 deg. to 252 deg. and thence to a pressure of 5 atmospheres. In less than 15 minutes, 33 lbs. of water of 212 deg. were raised to 307 deg. Finally, in favorable weather, 11 lbs. of water have been evaporated per hour. The steam generated was employed for driving a pump.

The inventor of this ingenious apparatus points out various uses for which it may be employed, especially in warm climates, as, for example, for the distillation of water, either on shipboard or in rainless conntries, for the manufacture of ice in connection with the Carré apparatus for the distillation of alcohol, etc., and in the manufacture of sugar.

Internal Constitution of Magnets.—In the *Comptes Rendus*, for January 3d, 1876, M. J. Jamin shows that a bundle of steel plates will always be stronger than a single bar of steel of the same dimensions, and the proportion will increase indefinitely with the number of the plates. This view justifies the use of slender laminæ in he construction of magnets.

COTTON MANUFACTURE AND THE RING FRAME.

By F. H. Silsbee.

(Continued from Vol. ci, page 101.)

Plate III, Figs. 1, 2, 3, 4, 5, 7, show some of the forms of bobbins which have been used, all except Fig. 7, having projections on the spindle which fit into the recesses shown. In Fig. 7, however, there is a spring in the bobbin which presses against the spindle, and thus holds the two together. The method, however, which is most generally used at present, is to drive them merely by the friction of the close-fitting bobbin on the spindle, notwithstanding the objection suggested by Mr. Leigh.

There has been an almost endless variety of spindles and bobbins invented, and a few of them are shown in Plates II, III, IV. The most important of all these, and those most in demand at present, are : 1st. The ordinary spindle, of which that manufactured by the Saco Water Power Company may be taken as the type, which consists of a steel rod 16½ inches long, tapering from about the middle towards each end, the largest diameter being about ⅝ inch, the smallest at the top ⅛ inch, and at the bottom ¼ inch. The wheel is placed about six inches from the bottom, and the whole weight of the spindle is about 12 ounces, although some have been made by this company as light as 7 ounces.

2d. The Sawyer Spindle, of which a drawing is shown in Plate III, Fig. 6. The bobbin is driven by friction, as in the ordinary spindle, but its distinctive feature is that the bolster *b*, is made very long, running almost half-way up inside the bobbin. This arrangement of bolster gives the requisite steadiness without necessitating such a long spindle as the common one is, and thus its weight is reduced to only about 3 or 4 ounces. The diameter of the step is also much less, being only ⅛ inch, and this fact, combined with the weight, must make the friction considerably less ; but I will discuss this point at more length farther on. There is one objection made to the Sawyer and other short spindles, which seems quite reasonable ; and that is, the inconvenience in banding them, in consequence of the step and bolster rails being so near together.

3d. The Rabbeth Spindle, Plate IV, which is also a very light spindle, and the bolster has a chamber which is kept filled with oil, so that the step is kept constantly lubricated, and the oiling only has to be done once in two or three weeks.

4th. The Excelsior Spindle, the peculiarity of which is, that there is a square button on the spindle, which fits a recess in the bobbin; but this necessitates the stopping of the spindle when the bobbin is removed.

5th. The Pearl, which is another of the light spindles. (Plate IV.)

All these various spindles, and a good many more which I have not mentioned, have their admirers, and it would certainly seem from a theoretical consideration merely, that a light spindle, provided it could be run as steadily, would require the least power; but, of course, the real merits of any particular spindle can be arrived at only by a practical trial.

The following is the power required to drive various kinds of frames, taken from some tests made by Mr. Webber, which were published in the report of the New England Cotton Manufacturers' Association, for 1873. The speed, in all cases, was 6000 revolutions per minute.

No. 30 Yarn.

	Ft. lbs. per Sp.
Heavy Spindle, ordinary ring-spinning,	7·15
Light " " "	6·10
Mason's Light Spindle, at Crescent Mills,	4·40
Rabbeth Spindle, at New Bedford,	4.10
American Linen Co.'s Spindle, at Fall River,	4·10
Garsed & Jenks' Spindle, at Philadelphia,	3·40

No. 40 Yarn.

Sawyer Spindle, Old Bolster, Fall River,	3·00
" " New " Manville,	2·80
Garsed & Jenks' Spindle, Manville,	2·45

The matter of rings is also one which has called forth a good many inventions. Plate III, Fig. 9, shows the form of the ordinary ring excepting the projection *C*, the object of which is to clear the loose threads from the traveler; but I don't think this appendage is often used. There is also usually a shoulder just below the junction of *C* with the ring, the lower part of the ring up to this shoulder being set in the ring rail. The objection to this sort of ring driven

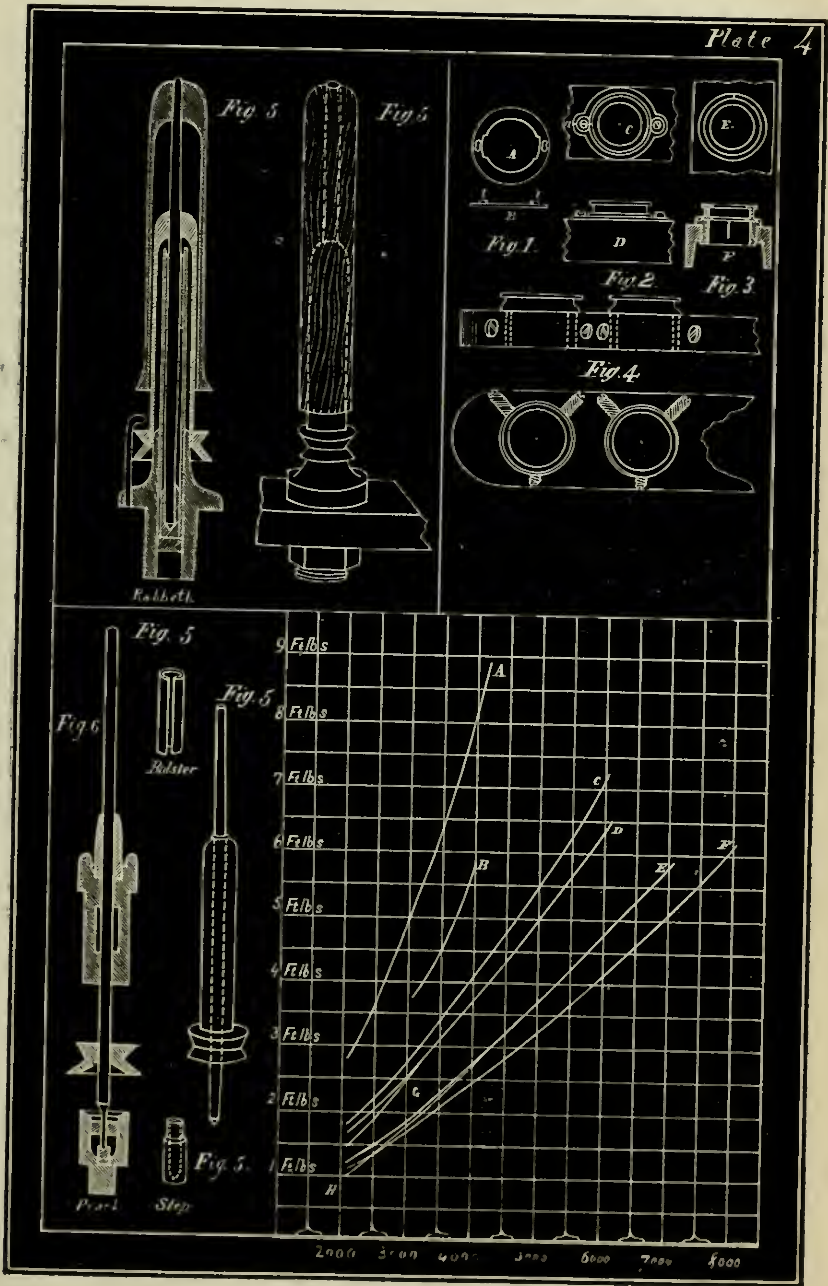


Plate 4
Fig. 5
Fig. 5
Rabbeth
Fig. 1
Fig. 2
Fig. 3
Fig. 4
A
B
C
D
E
F
Fig. 5
Fig. 6
Fig. 5
Bolster
Fig. 5.
Pearl
Step
9 Ft lbs
8 Ft lbs
7 Ft lbs
6 Ft lbs
5 Ft lbs
4 Ft lbs
3 Ft lbs
2 Ft lbs
1 Ft lbs
G
H
2000
6000
8000

firmly into the rail, is, that if through any accident the hole in the rail is not exactly concentric with the spindle, it cannot be adjusted; therefore, various forms of rings have been invented to obviate this difficulty. Plate IV, Fig. 4, shows one form of adjustable ring invented by Mr. W. Jenckes, of Manchester. As will be seen from the drawing, the hole in the rail is bored larger than the ring, which is held in place by three set screws. Plate III, Fig. 8, shows another method, which consists in having a hoop of metal, with its exterior turned eccentric with its interior, fitted into the rail so that it can be turned round, and into this, the ring seating, its exterior also eccentric with its interior, is fitted. Plate IV shows various forms of ring supporters, Fig. 1, *A*, *B*, being a form invented by Mr. Shorey, which consists of a flat ring of metal, having a lip turned up as shown at *l*, and the ring being sprung under these, is held in place. Fig. 2, *C*, *D*, is a somewhat similar arrangement, invented by Mr. Sawyer, the principal difference being that the projecting lip is made all around the supporter, which is split as shown at *a*, in order that the ring may be slipped in place. Fig. 3 is another similar arrangement, patented by Mr. Draper. All these forms are specially suited for duplex race rings; that is, those having a smooth flange on the top and bottom, so that the ring can be turned over when one face becomes worn.

Let us now compare the merits of the three methods of spinning. It is generally admitted that the throstle yarn is the strongest and smoothest of the three kinds, and a good many manufactures consider that it weaves easier; but then the throstle requires more power, and can do less work in the same time. The ring yarn is stronger than the mule, and is better for the warp. The ring frame also requires a good deal less power than the throstle, although it makes a little more waste. It takes up very much less room than the mule, though it takes a little more power on the average. Several attempts have been made to spin the filling on the ring frame, and some very good cloth has been produced, but there seem at present to be several objections to its general use for filling; in the first place, the cloth woven in this way is rather harsher, owing to the necessity for putting more twist in the ring yarn; and in the second place, the shape of the bobbin is a great objection. The twist is also more even in the mule than in the ring yarn, from the fact that the yarn is stretched while being twisted, and thus any

inequalities are evened out, so that the twist does not find small places to settle in, leaving the larger parts supplied with less twist, as is apt to be the case on the ring frame. The following are the results of some tests made by Mr. Cumnock and Mr. Francis, on the strength of different yarns, and the power required to run the various kinds of spinning machines:

Throstle Frame,	No. 32 Yarn.	Twist,	27·14.	B. Strength,	52 lbs.
Ring	"	"	"	27·20.	" "	48 "
Mule	"	"	"	27·16.	" "	41 "

POWER.

Throstle,	73	sps. per H. P.	No. 32 Yarn.	Rev. of sp. per min.	4200
Ring,	102	" "	"	" "	5900
Mule,	296	" "	"	" "	5650

QUANTITY.

"As the twists per inch in this test were the same, or nearly so, on the three kinds named, of course the largest quantity were produced from the ring frame; then the mule; and the throstle last. The quantity, of course, would be as the speed of the spindles, everything being equal." The diagram scale on Plate IV shows the power required for different spindles, plotted from experiments made by Mr. Francis, and which are published in the report of the New England Cotton Manufacturers' Association. In this diagram, the ordinates represent foot pounds of work required, and the abscissæ the number of revolutions of the spindles per minute.

The following results of experiments made by Mr. Webber, published in one of the reports of the association above alluded to, show the advantages of various methods of banding. The tests were made:

First. On ring frames, with every spindle banded separately.

Second. With 16 spindles in a section, all on one side.

Third. With 16 spindles in a section, 8 on each side.

Fourth. With 8 spindles in a section, 4 on each side, and with the following result:

	Single Band.	16 One Side.	8 Each Side.	4 Each Side.
Rev. F. Roll,	84	84	84	84
Rev. Spindle,	5666	5666	5666	5666
H. Power, 128 Sp.,	1·667	1·707	1·485	1·364
Ft. lbs. per Sp.,	7·26	7·33	6·38	5·86
Spindles per H. P.,	77	75	86	94

These results were so striking, that after being confirmed by a second day's trial, it was decided to test the throstle frames in the other mills of Pepperell Co., which gave:

Mill No. 1, Pepperell Co., Old Lowell Throstle. Weight of Flier, 3·45 ounces.

	16 One Side.	8 Each Side.	4 Each Side.
Rev. F. Roll,	71	71	71
Rev. Spindle,	4929	4929	4929
H. Power, 128 Sp.,	2·002	1·924	1·845
Ft. lbs. per Sp.,	8·60	8·27	7·92
No. Spindles per H. P.,	64	66·2	69

Mill No. 2, Pepperell Co., Lowell Throstle, with Pearl's Improved Flier. Weighing 2·83 ounces.

	16 One Side.	8 Each Side.	4 Each Side.
Rev. F. Roll per minute,	71	71	71
Rev. Spindle,	4929	4929	4929
Horse P., 128 Spindles,	1·686	1·687	1·528
Ft. lbs. per Spindle,	7·24	6·90	6·57
Spindles per H. P.,	76	79·75	83·75

"It was not thought necessary in these mills to repeat the trials of single banding, as the previous trials on ring frames had shown an advantage in it of about two per cent. over banding 16 spindles in a section on one side, while these trials showed an average of 5 per cent. in favor of banding 8 on each side, and 4 per cent. in favor of 4 on each side.

"The cause of this saving of power seems to be this: That the drums or cylinders are kept exactly in the centre of the frame, by this mode of banding, without any unequal pressure on either side, such as would be inevitably caused by a tight band, if put on in the usual manner; and it may be worth while to follow the experiment still farther, testing 4 spindles in a section, 2 on each side, and even down to 2 spindles banded directly across the frame, with one turn round the cylinder in the centre."

It may not be out of place here, before taking up the subject of twist, and one or two other calculations in regard to the ring frame, to say a word or two on the manner in which yarn is numbered.

The number given to cotton yarn, is in all cases the number of hanks which it takes of that yarn to weigh one pound. Thus, when No. 27 yarn is spoken of, it means that 27 hanks weigh one pound.

Now, a hank is 840 yards or 2520 feet; therefore, it takes 12·86 miles of No. 27 yarn to weigh one pound.

The numbers of the yarn used for ordinary cloth may vary from 20 to 100, although coarser numbers are used for making cotton duck, and finer numbers are employed for laces and muslins, very seldom exceeding No. 300; it is stated, however, that Messrs. Houldsworth, of Manchester, England, exhibited, in 1851, some lace made of No. 600, or so fine that it would take 286·66 miles to weigh one pound, and it also stated that the same firm exhibited some No. 2150, which would require 1026·13 miles to weigh one pound.

There is another point which it will be well to take up before considering the subject of twist, and that is, what relation exists between the speed of the traveler and of the spindle, a relationship which, at first sight, it does not seem very easy to determine. It is evident that if the traveler did not move, the yarn would be wrapped round the bobbin once for every revolution of the spindle, or else the yarn would break, and that if the traveler had the same speed as the bobbin, no yarn would be wound on; but now the traveler does move, and yet the yarn is wound on; therefore, evidently, the traveler must have a different speed from the bobbin; but, now what, exactly, is that difference? I hope the following explanation will make it clear. Consider, in the first place, that the yarn is stretched from the rolls, through the traveler, to the bobbin, and that the bobbin is then made to rotate rapidly, no more yarn being delivered. Evidently, if the yarn is strong enough, the traveler will have to make just as many revolutions as the bobbin, but the traveler has a tendency all the time to hold back, caused by its friction against the ring, and would therefore stop if it were not pulled along by the yarn. Now, suppose the circumference of the bobbin to be three inches, and let the front roll instantly deliver one inch of yarn; evidently the pull on the traveler will cease; therefore, the traveler will stop till the yarn begins to pull again, which will be when the 1 inch has been wound on. But since the circumference of the bobbin is three inches, the spindle must evidently make one-third of a revolution before the one inch is wound on. Therefore, the bobbin will have made one-third of a revolution more than the traveler. Hence, when the yarn has been wound about the bobbin once, the bobbin will have made just one more revolution than the traveler. Of course, in practice, the yarn is being constantly delivered, and the traveler never really stops, but the

tendency to do so, and the consequent diminution of speed of the traveler is the same; and we come to the following conclusion: That the difference between the number of revolutions made by the bobbin, and that made by the traveler, is equal to the number of times the yarn has been wound round the bobbin during the same interval of time.

Before giving the ordinary rules for calculating the twist, it is necessary to point out that there is a difference between the number of twists in the yarn as it lies on the bobbin, and the number of twists after the yarn is wound off in the usual manner; the former may be called the real twist, and the latter the apparent twist. This difference can perhaps be best explained by an example. If you take a piece of tape, and wind it spirally round a pencil, you do not appear to have twisted it all; but now pull the tape off the end of the pencil, holding one end of the tape firmly on the pencil, and you will see that the tape is twisted, and this shows the real twist which was in the tape while on the pencil, only it was not apparent. The apparent twist will be the twist left if you unwind the tape from the pencil, instead of pulling it off. In this case, the apparent twist will be nothing, because you untwist in removing the yarn, as much as you twisted in winding it on. Now, take a case a little more like what occurs in practice, and instead of winding up the tape for every revolution of the pencil, let it only wind up the tape once for every twenty revolutions of the pencil, and suppose you wind the tape four times around it, evidently the real twist will be 80, while the apparent twist is only 76. Now, this apparent twist is what is actually used in yarn made on ring frames, except where it is used for filling. Of course, if the one twist was always taken out of the same length of yarn, the twist per inch remaining would be the same for all parts of the bobbin; but such is not the case; for, as the bobbin increases in size, its circumference increases, and as there is one twist taken out for each wrap of the yarn around the bobbin, and this one twist has to be divided by the number of inches over which it extends, the number of twists per inch taken out must be less when the bobbin is full. I will give an example farther on to show how much error this causes.

I will now take an example to show the method of calculating the twist (real) put in the yarn when the speed of the cylinder and spindles, and the number of teeth on the wheels (if driven by gears),

or the diameters of the wheels (if driven by belts), which convey the power to the point roll are given. The example is taken from a ring frame made by the Saco Water Power Company, in the Naumkeag Mills, at Salem, the following data being given:

Speed of Cylinder, ...	870 revs. per min.	$= a.$
Diam. of Pulley on Cylinder, . .	4·75″	$= b.$
" " Twist Pulley, . . .	10·50″	$= c.$
Teeth in Twist Gear, ...	24	$= l.$
" " Gear on Front Roll, . .	132	$= f.$
Circumference of " . .	3·1416	$= k.$
Speed of Spindles, ...	6090	$= n.$

Then speed of twist gear = speed of twist pulley $= \frac{a \times b}{c} = \frac{870 \times 4{\cdot}75}{10{\cdot}5} = 393{\cdot}57 = d.$ Speed of front roll $= \frac{d \times l}{f} = \frac{393{\cdot}57 \times 24}{132} = 71{\cdot}55$ revolutions per minute.

$\therefore$ Number of inches of yarn passed through the front rolls, per minute $= 71{\cdot}55 \times k = 224{\cdot}667$. $\therefore$ The number of twists put in one inch of yarn $= \frac{n = 6090}{224{\cdot}667} = 27{\cdot}10$, which gives the real twist per inch. To calculate the mean apparent twist, we must divide the number of inches delivered by the front roll, by the mean speed of the traveler, which we will consider to be the speed when the bobbin is half full. Now, when the bobbin is half full, its circumference is usually about 3·1416. $\therefore$ According to what has already been said, the speed of the traveler $= 6090 - \frac{224{\cdot}667}{3{\cdot}1426} = 6018{\cdot}49$. $\therefore$ The mean apparent twist $= \frac{6018{\cdot}49}{224{\cdot}667} = 26{\cdot}78$. Calling the mean speed of the traveler n', we have for the general formula for finding the twist,

$\frac{n \times c \times f}{a \times b \times l \times k}$ = the real twist per inch.

$\frac{n' \times c \times f}{a \times b \times l \times k}$ = the mean apparent twist per inch.

Now let us see how much inequality there is in the apparent twist, arising from the varying size of the bobbin; and for this purpose we will calculate the twist at three points, *i. e.*, when the bobbin is empty, when it is half full, and when it is full, and we will take the

same yarn that we used before, for which the real twist is 27·106, the following data being given :

Circumference of empty	bobbin	= 1·57 inches.
" " half full	"	= 3·1416 "
" " full	"	= 4·712 "

Then in the 1st case, the twist taken out per inch $= \frac{1}{1\cdot57} = \cdot6369$.

In the 2d case, $\frac{1}{3\cdot1416} = \cdot3185$. In the 3d case, $\frac{1}{4\cdot712} = \cdot2123$.

∴ We have for the apparent twist per inch :

In the { 1st case, 26·469.
2d case, 26·787.
3d case, 26·8937.

This calculation shows that there is a little difference in the twist at different points in the yarn, but this is so slight that it may be neglected in practice ; and, indeed, some manufacturers take the amount of real twist for the apparent twist.

There might at first thought seem to be an unevenness of twist arising from the constantly varying distance of the ring rail from the front rolls. But I think it can be proved that this makes no error. Let the distance from the front roll to the traveler, when the ring rail is in its lowest position, be greater than the distance to the traveler, when the rail is in its highest position, by a quantity c, and let $S =$ the circumference of the bobbin, and $d =$ the amount of yarn passed through the front rolls per minute. Then, when the ring rail is in its highest position, the time taken to wrap the yarn once round the bobbin $= \frac{S}{d}$, and in the time $\frac{S}{d}$, the spindle will make $\frac{S}{d} \times n$ revolutions. So that the real twist per inch $= \frac{S}{\frac{Sn}{d}} = \frac{d}{n}$.

When the ring rail is in its lowest position, the amount of yarn required to reach the bobbin and wrap once around it, will be greater by c than the length required before. ∴ The time required to wrap the yarn once round $= \frac{S + c}{d}$ and in that time the spindle will make $\frac{(S + c)\,n}{d}$ revolutions. So the number of twists per inch =

$$\frac{\frac{S+c}{(S+c)\,n}}{d} = \frac{d}{n}.$$ ∴ The amount of twist which will be put in one inch is the same in both cases, and is, therefore, independent of the position of the ring rail. If the real twist does not vary, the apparent cannot.

The amount of twist put into the yarn varies with the number, the customary rule being: No. of twist per inch $= c\sqrt{\text{No. of the yarn}}$, the value of c being taken by some as 5, by others, 4·5. Examples: Required the number of twists for No. 9 yarn. Answer, $5\sqrt{9} = 15$.

The number of twists for No. 25 yarn $= 5\sqrt{25} = 25$.

The number of twists for No. 100 yarn $= 5\sqrt{100} = 50$.

Thus it will be seen, that the number of twists may be greater, as well as less than the number of the yarn.

To calculate the actual draught on a ring frame with the following data given:

Back roll gear, ...	84 teeth.
Stud gear, ...	84 "
Front roll gear, ...	30 "
Diameter of back roll, ...	$\frac{7}{8}$ inch.
" " front "	7 inches.
Pinion gear, ...	37 teeth.

The draught $= \dfrac{84 \times 84 \times 8}{30 \times 7 \times 37} = 7·26.$

The draught is changed by changing the pinion gear, which together with the stud gear is placed on a movable stud for that purpose. Required the number of teeth x on the pinion gear, for a given draught D, the data being the same as before:

$$x = \frac{84 \times 84 \times 8}{30 \times 7 \times D} = \frac{268·88}{D}.$$

The amount of draught depends on the relative speed of the front and back rolls, and the twist on the actual speed of the front roll with regard to speed of spindles. The spindles are run at the same speed, whatever the number of the yarn. Almost all the yarn finer than No. 60, is spun on the mule, and most spinners think it is impossible to spin any finer yarn on the ring frame, but a gentleman who has had great experience in spinning fine yarns, told me that this was a mistaken idea, and that by using long stapled cotton, he had spun No. 80 on the ring frame, and intended to spin No. 100.

The following calculation shows the speed of the traveler through space when under the following conditions:

The number of revolutions of the spindle = 6000 per minute.

The average circumference of bobbin = 3 inches.

The amount of yarn delivered by front roll = 224·667.

The radius of the path moved through by the centre of the traveler = $\frac{7}{8}$ inch.

Then the number of revolutions the traveler will make per minute $= 6000 - \frac{224{\cdot}667}{3{\cdot}1416} = 5925{\cdot}12$.

And the space passed through in one revolution $= 2\pi \times \frac{7}{8} =$ 5·4978″, and for 5925·12 revolutions = 32570·384 inches per minute = 1954222·8 inches = 30·84 miles per hour.

We will now examine the difference between the power required to drive the Saco spindle and the Sawyer spindle, and endeavor to see what proportion of this saving of power is due to the difference in weight.

First, to determine the friction of the Sawyer spindle, with the following data given:

Weight of Sawyer spindle, with empty bobbin = 3·5 ounces.

Number of revolutions per minute = 5000.

Diameter of step = 1-16 inch. ∴ Radius of step = 1-32 inch.

Conical pivot, the sides making an angle of 90° with each other.

Coefficient of friction $= f = {\cdot}07$.

We have the following formula for the friction of conical pivots:

$$\text{Total work of friction} = \frac{\pi n r f W}{15 \sin \alpha}.$$

Where $\pi = 3{\cdot}1416$.

n = number of revolutions per minute.

r = radius of the pivot in feet.

f = the coefficient of friction.

W = the weight in pounds.

$\alpha = \frac{1}{2}$ the angle between the sides.

Substituting in this formula the values given above, we have the

$$\text{friction} = \frac{3{\cdot}1416 \times 5000 \times {\cdot}07 \times 3{\cdot}5}{15 \times {\cdot}70711 \times 32 \times 12 \times 16} = {\cdot}059 \text{ ft. lbs. per second.}$$

Now, we have for the whole power required to drive the frame at 5000 revolutions per minute on No. 30 yarn = 3·25 ft. lbs.; therefore, the percentage of that power required to overcome the friction

arising from the weight and diameter of the step alone = ·0182 per cent. Applying the same formula to the McMullen (Saco) spindle, where the following data are given :

Weight of spindle with empty bobbin, 11 ounces.
Number of revolutions per minute, 5000.
Diameter of step, $\frac{1}{4}$ inch.
Angle of pivot = 90°. $\therefore$ $a = 45°$.
Coefficient of friction = ·07.

We have for the total work of friction $= T' = \frac{3{\cdot}1416 \times 5000}{15 \times {\cdot}70711} \times \frac{1}{8 \times 12} \times {\cdot}07 \times \frac{11}{16} = {\cdot}74$ ft. lbs. per second. Now, the power required to drive this frame on No. 30 yarn, at 5000 revolutions per minute = 5·1 ft. lbs. per spindle. $\therefore$ The percentage of power wasted in overcoming friction due to the weight of the spindle and empty bobbin, and diameter of step = ·0145 per cent.

The difference of power required to drive the two different frames = 5·1 — 3·25 = 1·85 ft. lbs., while the difference in the amount of work lost by friction = ·74 — ·059 = ·681 ft. lbs. ; therefore, the percentage of the saving due to the difference in friction = 36 per cent. The same calculation would apply almost equally well to the Rabbeth spindle, which is of about the same weight. This calculation seems to show that only a comparatively small proportion of the saving of power, found in using these light spindles, is due to their less weight. The rest of the saving is due probably to the smaller diameter of the bolster bearing, and to the fact that, since less power is required, the band does not have to be drawn so tight, and, therefore, there is very much less friction at the bolster.

The tightness of the bands is always a matter which makes a great difference in the power required to drive any frame, and, as the bands have to be adjusted by guess, it is probable that in most cases they are made considerably tighter than is necessary, from the desire to be sure and have them tight enough, and it is a well-known fact, that if, after a test has been made, the bands are cut, and the frame rebanded, the power required will be very different from what it was before.*

* The bands, as originally placed, require much extra power from unnecessary tension ; but after running some time, they stretch to the least point of tightness demanded, and then run with a minimum expenditure of power, before the spindles fail to have requisite speed.

I have endeavored in this paper to point out some of the advantages and defects in the ring frame, and some of the various spindles employed.

There seems to be now no doubt but that the ring frame is, in many respects, a great improvement over the machines formerly used for spinning, especially for spinning the warp; but still there is room for improvement in this machine, as well as in all the others employed in the cotton manufacture, and a vast amount of attention has been paid to the subject, especially to the reduction of the power required to drive spindles. It may at first seem that the saving of one or two foot pounds per spindle is a very slight matter, but it must be remembered that each frame has from 180 to 190, spindles, and when we take into account the number of spindles every mill has, this little saving amounts to quite an important item.

Immense as has been the improvement both in the machinery and reduction of cost of manufacture in this country since the first factory was built at Beverly, it does not seem improbable that there may be still further improvements in the future, as important, though perhaps not so marked as those which have already been made; and we may justly congratulate ourselves that Americans have helped not a little in the rapid growth of this industry by their improved steam engines and water wheels, and their methods of belting and shafting, which have had a great influence on the increase of the cotton manufacture.

THE UNDERGROUND TELEGRAPHS OF LONDON.*

On the 8th inst., at the meeting of the Society of Telegraphic Engineers, held at the Institution of Civil Engineers, Great George Street, Westminster, the president, Mr. Latimer Clark, in the chair, an interesting paper on "Underground Telegraphs; the London Street Work," by Charles Fleetwood, of the Postal Telegraph Department, was read.

The author stated that from the original five wires used by Cooke & Wheatstone, in July, 1837, between Euston and Camden, to test the success of the original five-needle telegraph, the system has gone on increasing latterly with rapid strides, culminating at the present time with 750 different wires entering the central station, and a total

* From the *Builder*, London, December 18th, 1875.

mileage of 3500 miles of gutta-percha covered wire. On the successful issue of the Cooke & Wheatstone telegraph, it was started commercially; and a line of five wires was placed underground in lead pipes between Paddington and Drayton. This line became defective, and in 1841 was replaced by posts and overhead wires. The existing lines erected by Mr. Cooke, from this period, were, in 1846, on the incorporation of the Electric Telegraph Company, led by wires in iron pipes to the first office in London, 345 Strand. In the following year, the system was extended under the streets to their new Central Station, at Founder's-court, Lothbury, which office was opened January 1st, 1848, when the total system of the company at that time reached 1500 miles of telegraph wire erected and in progress, a mileage less than one-half the present system under the streets of London alone. The wires were formed into cables, and drawn through iron pipes; the wires were of No. 4 gauge. These cables were connected to what were termed testing posts, standing up like a street post. The wires were connected in these boxes by a mechanical joint, which it was easy to open and disconnect for testing.

At the present time, the street work of London consists of about 3500 miles of No. 7 gauge gutta-percha covered wire, wrapped with tape, and tarred, drawn into cast iron pipes of 3 inches, and in some cases 4 inches diameter. This system connects the central office at St. Martin's-le-Grand with the several provincial railways, and the main road lines of telegraphs; it also serves a large number of the metropolitan telegraph offices. After describing the main routes of the pipes through the various districts of London, for a length of 110 miles, the author went on to state, that at the New General Post-office, the whole of the 740 wires are carried up the interior of the building, and terminate on a test box, where each wire is numbered. Provision has been made on this box for 500 wires from the west, and a corresponding number from the east, a total of 1000 in all. A 4-inch pipe will hold 120 wires of No. 7 gauge prepared, and a 3-inch pipe 72 wires; but it is not well, unless compelled by circumstances, to draw in those numbers. The pipes are 9 feet long, and previously to being laid, are well cleaned inside by having a heavy chain or mandril drawn to and fro to rub off any superfluous substance left in casting. The socket joints are packed with tarred yarn, and lead run in, as in the case of gas or water pipe joints.

In marking out the route, the footpath is generally chosen, and the pipes are laid under the pavement, it being more accessible, especially since the asphalt has been introduced. Flush-boxes 2 feet 6 inches long, 11 inches wide, and 1 foot deep, are fixed, in some cases 50 yards apart, and in others 100 yards, according to the number of wires required, and the nature of the streets. A No. 8 galvanized iron wire is threaded through the pipes from box to box, as the pipes are laid, by which the cables are hauled through. All the cables are sent out from the Postal Stores in lengths of 400 yards. On arrival at the place where they are to be used, the cable is coiled in a loop, a short distance from the centre flush-box of the 400 yards length. The ends of the wire are trimmed for about 6 inches. The cable is then divided into two, and each portion being twisted, is then passed through the loop in the iron leading-in wire in contrary directions, beaten back, and secured. A piece of canvas is then wrapped round and fastened with string. An iron frame with wooden rollers is then fixed in the flush-box. The cable is made to pass over one roller and under the other, and the latter is so arranged that the cable enters the pipe with a clear lead, and without being chafed against its edges. All being now ready for the drawing in, two men stand within the coil cutting the ties, and delivering the cable to a third man over the flush-box, whose duty it is to see that the cable enters the pipe evenly, the foreman standing near, so as to watch the cable entering the pipe, and to signal to the men at the next box when to commence or cease pulling. When the first 50 yards of cable have entered the pipe, which is known by the end appearing at the next box, a piece of tape is tied round the cable; and when this has passed through the pipe, a second piece, and so on, till the 200 yards have been drawn through. As the cable comes out of the pipe, it is coiled on the opposite end to that from which it has been drawn; the cable is then turned over by being re-coiled on to the contrary end of the box ready again to enter the pipe. This operation is repeated till the whole 200 yards have been laid. A corresponding operation has to be performed with the remaining 200 yards of the cable, but, of course, in the opposite direction. As soon as a few sections of the cable have been laid, the jointers follow, starting from the Central Station, St. Martin's-le-Grand, and jointing the wires in the vaults under the pavement at the corner of Bath Street, Newgate Street, to the house wires leading from the

test-box in the instrument-room, and which pass through a rack numbered to correspond with the terminals on the test-box. Having completed the joints at that spot, one man proceeds to the next joint-box, 400 yards distant, and the other to the test-box, where he commences numbering the wires by putting the current on the lowest number through a galvanometer, and when found by the man in the flush-box, three signals are passed twice each way. The wire is then fitted with a small piece of composite tube, on which a number has been stamped corresponding with the test-box number. Every wire is numbered in this way at the 400 yards boxes, so that at every joint box the number of any wire is at once known. The men engaged in this work in London have had great experience, and although the whole of their joints will not, perhaps, to use their own phrase, " stand the shadow test" (Thomson's Reflecting Galvanometer), they are generally good. The greatest enemy they have to contend with is dirt, and although full instructions are issued, and every care taken, it is difficult to carry them out thoroughly in the streets of London. There have been several methods proposed for improving the joints in the streets, but as yet they have met little favor from those engaged in the work. It has been the custom to make a twist-joint, and now it has been suggested to insert the ends after being cleaned, into a piece of slit copper tube, tinned on the inside, of about $\frac{3}{4}$ inch in length, after which it is soldered. This makes a good joint, and it is believed will prove beneficial, as it does away with the sharp points that must be left when a twist is made. A plan for insulating joints is on trial at several places. The two wires are passed through the wooden bottom of a short tin tube, the twist made and soldered, and then the wires pulled back into the tube, and the latter filled with melted paraffine wax. Such a system of mechanical jointing of course could not be used where it would be necessary to draw the joints through a pipe.

On the subject of maintenance, the author stated that within the past five years nearly the whole of the underground system in London has been re-laid, the number of wires having been found insufficient to meet the increased metropolitan traffic, as well as the additional wires rendered necessary on the railways and road lines for the rapidly developing provincial business. This work has been effected with comparatively little or no interruption of the working circuits, and by far less than is experienced from renewals on railways or road lines.

The underground wires are tested periodically from the Central Station by means of a Wheatstone bridge and Thomson's galvanometer. To prevent stopping the circuit, two spare wires (where available) are used between St. Martin's and the point to which the tests are to be taken: one joined to an instrument for a speaking circuit, and the second as a substitute for the working wire during the time it is being tested. . . . During the latter portion of the time that the old building in Telegraph Street was in use, it frequently happened that a wire was worked out of a mass where there was nothing to identify it by. In that case, rather than prick the wires, a wire-finder, such as mentioned by Mr. Culley, in his Handbook of Practical Telegraphy, was used, but it was found to be a difficult task, owing to the currents in the working wires affecting the needle. Eventually it struck the author, that if he used a quantity current, and the horizontal galvanometer, generally used for the Wheatstone Bridge, he should succeed. It proved to be correct; the quantity current only moving the needle. This plan has since been used in the street, and answers admirably. In conclusion, the author expressed a hope that he might see the underground system extended far beyond the outskirts of London, believing that if the same care and attention were given to it as is given to submarine cables, it would prove to be a great success.

RAINFALL ON THE BASIN OF THE SCHUYLKILL RIVER.

By Henry P. M. Birkinbine, C. E.

The following abstract from notes made during the years 1867 to 1870, when the writer was Chief Engineer of the Water Department of the city of Philadelphia, is presented with some hesitancy, because of its incompleteness as a full consideration of the subject. At the time of change in the office of Engineer, an extensive set of observations was in progress, or on the point of institution, which, after completion, would have permitted a thorough exhibition of the physical character of the district from which the water of Philadelphia is derived; as it is, however, the subjoined notes may possess some value for the purposes of estimate.

The Schuylkill River has its rise in the Blue Mountains, and flows about southeast, draining a diversified country, about one-half of which is mountainous or hilly, and all of it undulating.

Drainage Area.—The water shed above Fairmount dam includes an area of one thousand, nine hundred and forty two (1942) square miles and occupies parts of eight (8) counties, as follows:

Philadelphia County,	22	sq. miles.
Montgomery "	396	"
Bucks "	82	"
Chester "	161	"
Berks, "	841	"
Lehigh, "	73	"
Lebanon, "	43	"
Schuylkill, "	324	"
Total,	1942	"

Average and available rainfall.—The average annual rainfall upon this area is forty-five (45) inches; of this amount about 40 per cent. (eighteen inches) reaches the Fairmount dam, the remainder being lost by evaporation and absorption. The average rainfall was determined by a careful tabulation of monthly reports of observations made at various points in the Schuylkill valley; these reports extended in two instances, viz: Philadelphia and Lebanon, over a period of forty years. The following data formed the basis upon which the estimate of 18 inches available precipitation was made.

Boston.—The average rainfall collected from the area drained from Lake Cochituate, from which Boston is supplied, is forty-six (46) per cent. of the precipitation, vide: "History of the introduction of pure water into the city of Boston." Boston, 1868, table No. 2, page 275.

Brooklyn.—The ponds from which Brooklyn is supplied collect fifty (50) per cent. of the total rainfall upon their drainage areas, vide: "Brooklyn water works and sewers." New York, 1867, page 65.

Mississippi River.—In the "Report upon the physics and hydraulics of the Mississippi River," by Humphreys and Abbot, Philadelphia, 1861, page 136. The available percentage of the rainfall upon the drainage area is given as follows:

Small tributaries,	90	per cent.
Ohio River,	24	"
Upper Mississippi River,	24	"
Missouri River,	15	"
Entire Mississippi River, exclusive of Red River,	25	"

Croton River.—The minimum flow of the Croton River, by measurement, is 0·3 cubic ft. per second, for every one thousand (1000) acres; or one hundred and twenty-four thousand, four hundred and sixteen (124,416) gallons per day per square mile, vide: "Brooklyn water works and sewers." New York, 1867, pages 63 and 64.

Evaporation.—During the summer months the evaporation averages 0·115 inches per day from the surface of the water, vide: "Twentieth annual report of the Croton Aqueduct Department." New York, 1868, Doc. 2, page 10.

Daily flow of Schuylkill.—The average annual rainfall may therefore be assumed at forty-five (45) inches, of which eighteen inches is discharged into the Fairmount Pool: this will give a daily flow of one billion, six hundred and sixty-four million, three hundred and sixty-nine thousand and four hundred and thirteen (1,664,369,413) gallons.

Freshets.—In times of freshets, a very large amount of water wastes over the dam; this will probably reach an average throughout the year of one billion (1,000,000,000) gallons per day.

Ordinary flow of Schuylkill.—The daily average flow of the stream at its ordinary stages is therefore about six hundred and fifty million (650,000,000) gallons, which would give a head of five and one-half ($5\frac{1}{2}$) inches above the comb of Fairmount Dam.

20-*inch Freshet.*—A freshet of twenty (20) inches on the dam will waste over four billion (4.000,000,000) gallons per day.

25-*inch Freshet.*—The head of water on the dam May 3d, 1869, was twenty-five (25) inches; this is equivalent to a daily flow of six billion, six hundred million, six hundred thousand (6,600,600,000) gallons. And on September 27th, 1869, there was *a head of thirty-six* (36) inches on the dam, which is equivalent to a daily flow of thirteen billion, six hundred million (13,600,000,000) gallons.

Formula.—These calculations are based upon the formula $Q = 3{\cdot}01208lh^{1{\cdot}53}$, when $Q =$ cubic feet per second. This formula is given by Jas. B. Francis, C.E., and is the result of experiments made at Lawrence, Mass., on a dam having an overfall nine hundred (900) feet long, erected across the Merrimac River by the Essex Water Company, vide: "Lowell Hydraulic Experiments." Boston, 1865, and New York, 1868, page 136.

Effects of Forests.—The annual amount of water flowing in a river is about the same for each year, but by cutting off the forests and

cultivating the land, storm water flows off more rapidly and the amount of spring water is lessened, thereby augmenting the maximum and decreasing the minimum discharge of the stream, and causing the maximum and minimum flow to be more frequent and farther removed from the mean, vide: "Man and Nature," by Geo. P. Marsh, New York, 1864.

Noticed on the Schuylkill.—The effects of forests upon springs and streams of water has been frequently observed in the cutting off and the growth of chestnut trees, on the Schuylkill drainage.

Minimum flow.—The minimum flow of the Schuylkill is frequently less than two hundred million (200,000,000) gallons per day; as shown by the amount of water which is available for pumping in dry seasons.

Calculation of flow.—Taking as a basis of calculation the minimum flow of the Croton River, 0·3 cubic feet per one thousand (1000) acres; would give a discharge from the Schuylkill drainage of two hundred and forty-one million, six hundred and fifteen thousand, eight hundred and seventy-two (241, 615,872) gallons per day; from this must be deducted the evaporation in the summer months, viz: 0·115 inches. Assuming the superficial area of the river, dams, pools, etc., to be twenty (20) square miles; this amount will be thirty-nine million, nine hundred and seventy-one thousand, three hundred and thirty-nine (39,971,339) gallons—giving as the minimum flow two hundred and one million, six hundred and forty-four thousand, five hundred and thirty-four (201,644,534) gallons per day.

Store reservoirs.—During seasons of drought it was found not possible to maintain navigation by the natural flow of the river; it therefore became necessary to construct impounding reservoirs near the head waters.

Tumbling Run No. 1.—The first of these was completed upon Tumbling Run in 1834, vide: "Annual Report of the Schuylkill Navigation Company for 1834," page 6.

Tumbling Run No. 2.—A second was completed in 1837 upon the same stream, and both raised in 1840, to increase their capacity, vide: "Annual Report of the Schuylkill Navigation Company for 1840, page 9."

Silver Creek.—A third was constructed about 1854 upon Silver Creek.

Sizes and capacities.—The sizes and capacities of these reservoirs are as follows:

	Depth of water in ft. and in.	Area of water in Acres.	Contents in gallons.
Tumbling Run No 1, ...	53′ 8″	25·57	191,598,900
" " " 2, ...	57′	31·45	298,924,590
Silver Creek Reservoir, ...	37′	42·	320,853,750
Total Capacity,			811,377,240

Navigation interrupted.—When any one of these reservoirs was out of order, navigation of the river has been interrupted.

Reservoirs insufficient.—The total capacity of these reservoirs, eight hundred and eleven million, three hundred and seventy-seven thousand, two hundred and forty (811,377,240) gallons, is not sufficient to keep up the mean flow of the river at Fairmount for two (2) days.

Table of Rainfall.

TIME.	Philadelphia. Penna. Hospital, 40 years' observation.			Lebanon. Union Canal Office, 40 years' observation.			Norristown. Average for 9 years.	Philadelphia. Average for 18 years; John Kilpatrick.
	Monthly Average.	Monthly Maximum.	Monthly Minimum.	Monthly Average.	Monthly Maximum.	Monthly Minimum.		
December	3·948	7·378	1·044	3·31	6·68	0·86	3·97	3·798
January	3·502	7·837	0·730	3·11	5·61	1·09	3·82	3·179
February	3·022	6·615	0·551	2·54	5·05	0·56	3·17	3·306
March	3·47	6·985	1·087	3·07	6·65	0·59	2·6	3·536
April	3·638	7·750	0·585	3·29	5·67	0·57	5·10	4·354
May	4·025	8·685	1·07	4 56	10·65	1·17	4·50	4·973
June	4·237	11·025	1·100	4·38	10·05	0·49	4·41	4·688
July	3·864	11·805	0·985	4·00	11·43	0·39	3·67	3·534
August	4·399	15·816	0·62	3·37	12·91	0·80	4·22	4·411
September	3·774	9·519	0·249	3·5	10·20	0·71	4·34	4·529
October	3·287	10·05	0·66	3·33	7·39	1·14	2·96	2·951
November	3·493	7·970	1.450	3·25	6·65	0·70	3·71	3·613
Winter	10·472	16·677	5·434	8·94	15·31	5·06	10·96	10·279
Spring	11·133	17·650	6·594	10·96	16·71	5·82	12·21	12·989
Summer	12·5	29·228	6·256	11·79	22·05	5·86	12·30	12·416
Autumn	10·554	17·765	5·245	10·11	15·81	5·99	11·01	11·092
Year	45·884			42·126			46·48	46·948
Monthly Average	3·824			3·494			3·873	3·912

River below Reading.—The river below Reading is broader, the fall of the water is less rapid, the dams cover a larger surface, and

the evaporation is greater. The amount of water necessary to keep up the navigation upon this part of the stream will therefore be much in excess of the quantity required for the same purpose above Reading.

Average Summer rainfall.

Philadelphia for 40 years,	. . .	12·5 inches.
" " 18 "	. . .	12·416 "
Lebanon* " 40 "	. . .	11·79 "
Norristown, " 9 "	. . .	12·30 "
Average on Schuylkill drainage,	. .	12·251 "

Observations of declivity of the river.—Efforts have been made to determine the fall or declivity of the river, produced by the flow of a given amount of water. A number of simultaneous observations were made at five points, viz: Fairmount dam, under Columbia Bridge, under City Bridge at Falls, at Pencoyd Iron Works, and at Manayunk Locks.

Constant variations of declivity.—These observations demonstrate a constant variation, caused by starting and stopping the wheels at Fairmount Water Works, or at various factories, the lockage of boats, the direction and intensity of the wind, etc.

Calculation impossible.—The declivity cannot be determined by calculation, as there are no formulæ which meet the conditions of the river varying so much in width, with so many bends, and with a bed obstructed by rocks, shoals, coffer dams, bridge piers, etc.

Measurements made August 31, 1870.—The nearest approach to determining the correct declivity was made August 31st, 1870, when the estimated daily flow was five hundred and eighty-five million (585,000,000) gallons; the surface of the water under Columbia Bridge was two and three-fourths ($2\frac{3}{4}$) inches. The surface of the water under the City Bridge at Falls, three and a half ($3\frac{1}{2}$) inches. The surface of the water opposite Pencoyd Iron Works, five (5) inches and the surface of the water at Manayunk, six (6) inches. These heights are above the level of the water on Fairmount dam, and represent the approximate declivity of the river at its ordinary stage.

Practically no declivity during minimum flow.—The quantity of water flowing in the stream materially influences the fall. When the mills and navigation are stopped, and the flow of the water is reduced

* Lebanon is situated on the water shed dividing the drainage of the Schuylkill and Susquehanna, 86 miles from Philadelphia and 456 feet above tide.

to that which leaks through the locks, dams and wickets, there is practically no declivity in the stream.

Declivity during freshet, Oct. 4th, 1869.—The greatest recorded freshet in the Schuylkill occurred October 4th, 1869, when there was 11·46 feet of water on the Fairmount dam. The declivity of the surface of the water was over twenty (20) feet in six and two-thirds ($6\frac{2}{3}$) miles. The fall was not uniform, but consisted of a series of inclines and varied from less than a half ($\frac{1}{2}$) foot to nearly (10) feet per mile, vide: "Second Annual Report of the Commissioners of Fairmount Park," Philadelphia, 1870, pp. 39 and 40.

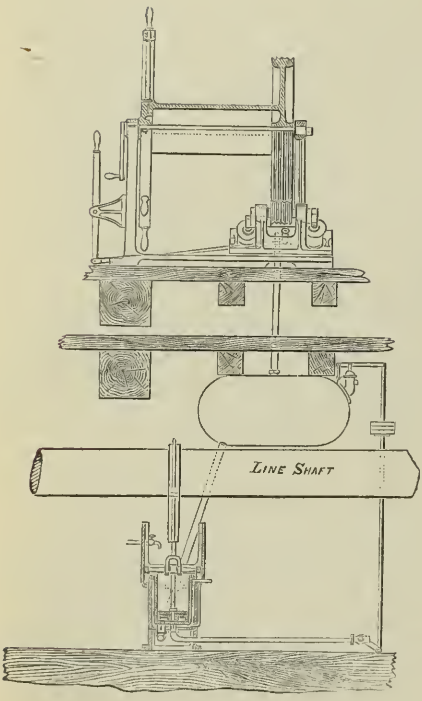
PNEUMATIC STEERING GEAR, DESIGNED FOR THE U. S. SLOOP OF WAR MOHICAN AND OTHERS OF THE SAME CLASS.

By G. W. Baird, Passed Assistant Engineer, U. S. N.

These new ships of war are unarmored, and are to compose part of our fast-cruising ships. They are to carry heavy ordnance, and to be full steam powered, and will, therefore, be well ladened with machinery, coal, ammunition, etc., leaving scanty quarters for the berthing of the crew. If, then, labor-saving machinery can be introduced, part of the crew may be dispensed with, leaving quite comfortable quarters for those employed. The Navy Department has recognized this condition of affairs, and is now introducing labor-saving machinery with this view.

But in these unarmored ships of war, steam steering gears cannot be used, as they are exposed to the shots of the enemy. Several power gears have been proposed, prominent among which are the hydraulic gears and screw gears, but have been rejected on account of their rigidity. When the rudder receives a blow from a surging wave, it must yield a little, or it will soon break, and for this purpose positive cushioning must be provided. To meet the requirements of this special case, a pneumatic arrangement has been designed in the Bureau of Steam Engineering, which has received general approbation.

It must here be mentioned that the ships of our navy, when proceeding under sail, uncouple the line shaft from the main engine, and permit the screw to revolve freely by the pressure of the water upon the blades, and with it, of course, that section of the line shaft aft of the coupling revolves.



Upon this line shaft is keyed an eccentric which works an air pump, and the air, forced by the pump is stored up in a reservoir to 55 pounds pressure above the atmosphere. Upon the *receiving* pipe of the air pump is a cock, which is opened or closed by the intervention of levers, a rod and a small piston within a cylinder on the reservoir, which is counterbalanced by weights on the rod. This arrangement is automatic, and regulates the supply of air to the pump, and the pressure in the reservoir. If the pressure should still increase (by leak of receiving valve) the piston rises still higher, and lets the air escape, as in the ordinary safety valve.

Upon the deck of the vessel is situated the old fashioned hand steering gear, except that it has upon its drum a large friction wheel (36″ diameter), and under the system a grooved pinion, geared into the large wheel, which pinion is upon the shaft of, and is driven by, a pair of oscillating engines (4″ diameter of cylinder, and 5″ stroke of piston). These little engines are driven by the compressed air from the reservoir referred to above. They are reversed by a two-way cock, which changes the steam port into the exhaust, and vice versa, and which is actuated by a lever which is placed vertically in front of the system. The motions of the cylinders open and close their ports (proper) in the ordinary manner.

The drum, upon which the tiller ropes are coiled, moves upon an iron axis, which passes through, and has upon its ends, eccentrics. By turning this axial shaft, it is made to rise or lower, and thus the power gear is thrown in or out of contact. When out of gear, it is worked in the ordinary manner. When the main engines are at work, the air pump is moved by the shaft, and the steering gear is worked

by that source; but when the main engines are *not* at work, the propeller is uncoupled, and the line shaft is revolved by its propeller, which is in turn revolved by the pressure of the water upon the blades when the ship is under sail and making headway. It may be stated here, that screws revolve freely when the vessel is moving at three knots per hour. If, however, the vessel moves at a lower rate of speed, the weather is then fine, and one man may steer with ease.

In addition to the advantages already noticed, this gear is very elastic, as a blow upon the rudder would move the system backward, and compress the air upon the piston, offering a uniformly increased resistance. But when the resistance of the engines equaled the pressure on the rudder, and the strain was still considerable, the friction gear would slide over before it would break.

FLYING MACHINES AND PENAUD'S ARTIFICIAL BIRD.*

By Alfred M. Mayer†, Professor in the Stevens Inst. of Techn'y.

(*Translated from the Journal de Physique.*)

Numerous attempts have been made at different times to construct a machine capable of propelling itself through the air. All kinds of aerial propellers have in turn been tried; such as screws, beating wings, umbrellas which open and shut during their reciprocating motion, inclined planes, aerial wheels. But though many of these projects called forth considerable inventive ability, yet, until quite recently, the *helicopteron* (from ἑλικός, anything spiral or twisted, and πτερόν, a wing—that is, a machine furnished with an aerial screw propeller) was the only type of machine which had succeeded in raising itself in flight. Several of these helicopterons have been constructed since 1784, at which date Bienvenu made the first that flew. The best known, and the most perfect, was that which Ponton d'Amécourt constructed in 1864, and which raised itself for a moment by a

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* The Academy of Sciences of Paris, at its meeting in June, 1875, awarded to M. Pénaud a prize for the discoveries and inventions described in this article.

† Extracted by permission from *Popular Science Monthly*, Feb'y, 1876.

sudden motion to a height of two and a half meters. It was formed of two superposed right and left handed screws, put in motion by a watch spring. All other methods of artificial flight, including those of propellers with wings beating the air like those of a bird, remained ineffective, and were the subjects of conflicting hypotheses as to the nature of flight.

In beginning our studies, we have thought that the best means of getting rid of the multiplicity of hypotheses and of conflicting opinions would be to divide the flying machines that have been invented into a small number of general types; then to reduce each of these types to its essential elements, and finally to design a flying machine of each of these simplified types possessing all the really essential parts, and easy to construct.

Leaving out of consideration the inventions which are evidently defective, we have thought it possible to divide the majority of the systems of artificial flight into *helicopterons*, *areoplanes*, and *orthopterons* (from ὀρθός, straight, and πτερόν, a wing). The helicopterons sustain themselves by the aid of screws whose axes of rotation are nearly vertical. They may be made to progress either by these vertical screws or by special screw propellers. The areoplanes have propelling surfaces which are nearly plane and slightly inclined to the horizon. A horizontal motion is given to these surfaces generally by means of screws. Finally, in the orthopterons, the propelling organs are surfaces moving in vertical directions, and generally having reciprocating motions. In this system are embraced the wings of birds and the moving surfaces of the tails of fishes.

The knowledge of the resistance of the air appeared to us the only guide by which we could arrive at a thorough understanding of the manner in which a machine could sustain itself by the actions of its propelling surfaces on this fluid. We entered upon an attentive study of several imperfectly understood points appearing to us of capital importance; such as the sustaining screw, the aerial inclined plane, and the theory of the equilibrium of flying machines. The screw propeller was well understood from its effects in propelling vessels. These researches, which led us to a small number of very simple general laws, permitted us to determine the manner of action and the proportions of the machines which we desired to construct.

It remained to find a motor the easiest of application. Wood, whalebone, and steel, give forces which are at a minimum when re-

ferred to their weight; caoutchouc is much more powerful, but the framework necessary to resist its violent tension is necessarily quite heavy. We then conceived the idea of using the elasticity of the torsion of caoutchouc, which finally led to an easy, simple, and effective method of constructing the models of flying machines.

We applied the new motor first to the helicopteron, after having previously investigated the curious and valuable actions of caoutchouc when subjected to various successive torsions. In April, 1870, we presented models to M. de la Landelle, which rose in flight to more than fifteen meters, hovering and fluttering through large inclined circles, and sustaining themselves during more than twenty seconds.

The great superiority of these results over those obtained with preceding helicopterons encouraged us to apply our motor to other systems of artificial flight. On the 18th of August, 1871, in the presence of the Society of Aerial Navigation, we succeeded in making an areoplane fly with various velocities and in different directions, around one of the circles of the gardens of the Tuileries. The success of this machine in its ascending motions and in its perfect equilibrium gave the first successful exhibition of a machine on the areoplane type.

Measured directly, and irrespective of any hypothesis, the force required to sustain and propel the areoplane and the helicopteron proved to be relatively moderate, and did not approach the fabulous estimations previously given by Navier. This experiment demonstrated that the muscular strength of birds, although notably greater, for equal weights. than that of mammals, did not exceed a reasonable estimation.

Our helicopterons and areoplanes which performed with success on the 2d of July, 1875, before the Physical Society, have a numerous offspring. They have been imitated with various success by Crocé-Spinelli and MM. Montfallet, Pétard, and Tantin.

The action of these machines, in fully confirming our ideas and calculations on the resistance of the atmosphere, encouraged us to attempt the construction of a mechanical bird with flapping wings. The diversity of the hypotheses as to the nature of flight, proposed in France and in England, though bearing witness to the difficulties to be met with in the construction of this mechanism, yet rendered the problem peculiarly interesting.

The experiments heretofore made with mechanical birds had been very discouraging. M. Artingstall and M. Marey had alone obtained effective results. M. Artingstall states that, some thirty years since, he had an artificial bird which flew at the end of a tube jointed on to a steam boiler. M. Marey, whose beautiful physiological experiments are so well known, constructed, in 1870, artificial insects, which, attached to a radial tube carrying a counterpoise equal to two-thirds of their weight, rose and flew in a circle by the aid of their wings. The compressed air which set the wings in motion was conveyed to them through the radial tube from a compression pump worked by hand.* It remained to gain the two-thirds of the weight of the insect and to cause the latter to carry with it its motor instead of having the wings moved by a force conveyed to the insect from without.

Encompassed by the divers hypotheses of the action of the wing given by Borelli, Huber, Dutrochet, Strauss-Durckeim, Liais, Pettigrew, Marey, d'Esterno, De Lucy, Artingstall, etc., and in view of the very complicated motions they had assigned to that organ and to each of its quills—motions which are, for the most part, inimitable in a mechanical bird—we decided to reason out for ourselves, by relying on the laws of the resistance of the air and on some of the most simple facts of observation. what are *the motions of the wing really necessary to flight.* We found—1. *A double oscillation*, a depression, and an elevation of the wings transverse to the path of flight. 2. The change of the plane of the same during this double motion; the lower surface of the wing facing below and behind during its depression, so as to sustain the bird, the same surface of the wing facing below and in front during its elevation, so that the wing is raised with the least resistance by cutting the air with its edge while the bird flies. These movements, moreover, were admitted to be correct by a large number of observers, and have been concisely demonstrated by Strauss-Durckeim, Liais, and Marey.

But, in considering the difficulty of the construction of our mechanical bird, we were obliged, notwithstanding our desire to make a machine which should be simple and easy to understand, to try to perfect those actions we have somewhat summarily described. It is evident that the different parts of the wing, from its base to its ex-

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* *See* Fig. 87, on page 202 of Marey's "Animal Mechanism," published in the "International Scientific Series.'

tremity, act on the air under very different conditions. The interior part of the wing, having small velocity, produces little propelling effect at any moment of its beat; but it is far from being useless, and one may imagine how, by presenting its lower face downward and slightly facing the front, it acts during the rapid translation of the bird, like a kite, as well while the wing is being elevated as during its downward motion, and thus sustaining in a continuous manner a portion of the weight of the bird. The middle portion of the wing has a junction intermediate between that of the interior and that of the outer portion, or end, of the wing; so that the wing, during its action, is twisted on itself in a continuous manner from its base to its extremity. The plane of the wing at its base varies but little during flight; the plane of the median part of the wing is very much displaced on one and the other side of its mean position; finally, the outer part of the wing, and especially its tip, experiences considerable change of plane. This warping of the wing is modified at each instant during its elevation and depression, in the manner just indicated; at the extreme points of its beat the wing is nearly plane. The action of the wing is thus seen to be intermediate between that of an inclined plane and that of a screw with a very long and continually variable pitch.

Notwithstanding the differences found to exist in the hypotheses of various authors when compared with one another and with the one just given, still one or the other of these writers confirms the greater portion of the ideas just advanced. Thus the torsion of the wing had already been pointed out by Dutrochet, and especially by Pettigrew, who long maintained this opinion; only he has taken, according to our view, the change of form occurring during the elevation of the wing for that of the form occurring during its depression, and *vice versa*. These authors clearly saw how the articulations of the bones, the ligaments of the wing, the imbrication and elasticity of the quills, bring about the above result. M. d'Esterno had explained the continuous effect, like that of a kite, of the interior portion of the wing during its depression and elevation; and M. Marey had very appropriately designated that portion of the wing as "passive," at the same time, however, maintaining that the most important action of the wing during flight is due to a general change of its plane produced by the rotation of the humerus on itself.

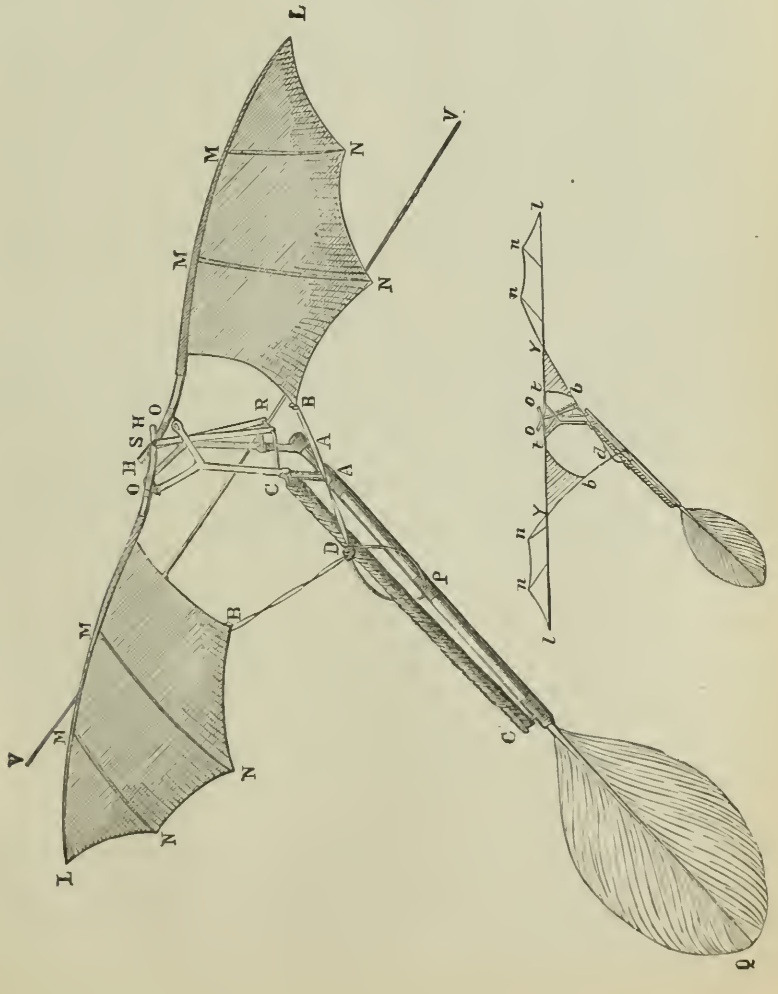
According to our view there is a sharp distinction to be made beween hovering and the ordinary flight of progression, while the am-

plitude of the changes in the plane of the extremity of the wing is essentially a function of the velocity of translation of the bird. At the extremity of the wing, where the most considerable changes of plane takes place, these changes equal 90°, and even more, during hovering; but then displacements of plane are far less in the flight of progression. According to our calculations the extreme portions of the surface of the terminal feathers of the crow's wing are, during free flight, inclined forward during the depression of the wing only from 7° to 11° below the horizontal, and from 15° to 20° above the horizontal plane during the elevation of the wing. The plane of the wing at its base acts during the above motions like a kite inclined at an angle only of from 2° to 4°.

It is easy to verify the slight inclination of the wing, and consequently the smallness of its angles of action in the air, by observing a flying bird moving in a horizontal line of sight, for we then see only the edges of the wings. It is, in short, inexact to say that the wing changes its *plane* : we can barely say that it changes its *planes.* The truth is, that it is gradually more and more warped in going from its base to its extremity. It was so understood, indeed, by an English author, whose labors we became acquainted with after we had constructed our bird, and to him we are indebted for having saved us several researches. The theory of Sir G. Cayley, published in 1810, differs from ours but in a few particulars. He is of the opinion that the outer portion of the wing in ascending exerts always a propulsive action, and he attributes to the propelling parts and to the sustaining, kite-like parts of the wing, proportions which are relatively the reverse of those to which we have been led by our calculation.

It was with these ideas, favorably judged of by the Academy in September, 1871, that we undertook the application of the torsion of caoutchouc to the problem of the mechanical bird. The wings of our bird are made to beat in the same plane by means of a crank and connecting rods. After several rough trials, we found out that the transformation of motion in the machine required a mechanism very solid relatively to its weight, and I requested M. Tobert, an able mechanist, to construct out of steel a piece of mechanism designed by my brother, E. Pénaud. The accompanying figure represents the apparatus so constructed ; *C C′* is the motor of twisted caoutchouc placed above the rigid rod, *P A A*, which is the vertebral column of

the machine; from this rod, at A and A, ascend two rigid forks, which serve below as supports for the crank, $C\ R$, which is attached to the twisted caoutchouc; and above, at the ends of the forks at O and O, are the pivots on which the wings oscillate. The links, $R\ S$, convert the motion of rotation of the crank into the reciprocating motion of the arms, $O\ M\ L$, $O\ M\ L$. At Q is a steering tail, which we found by experience was best made from one of the long feathers of a peacock's tail, and which can be inclined upward or downward, or to one side, and be loaded with wax so that the centre of gravity of the machine can be brought to the proper position.



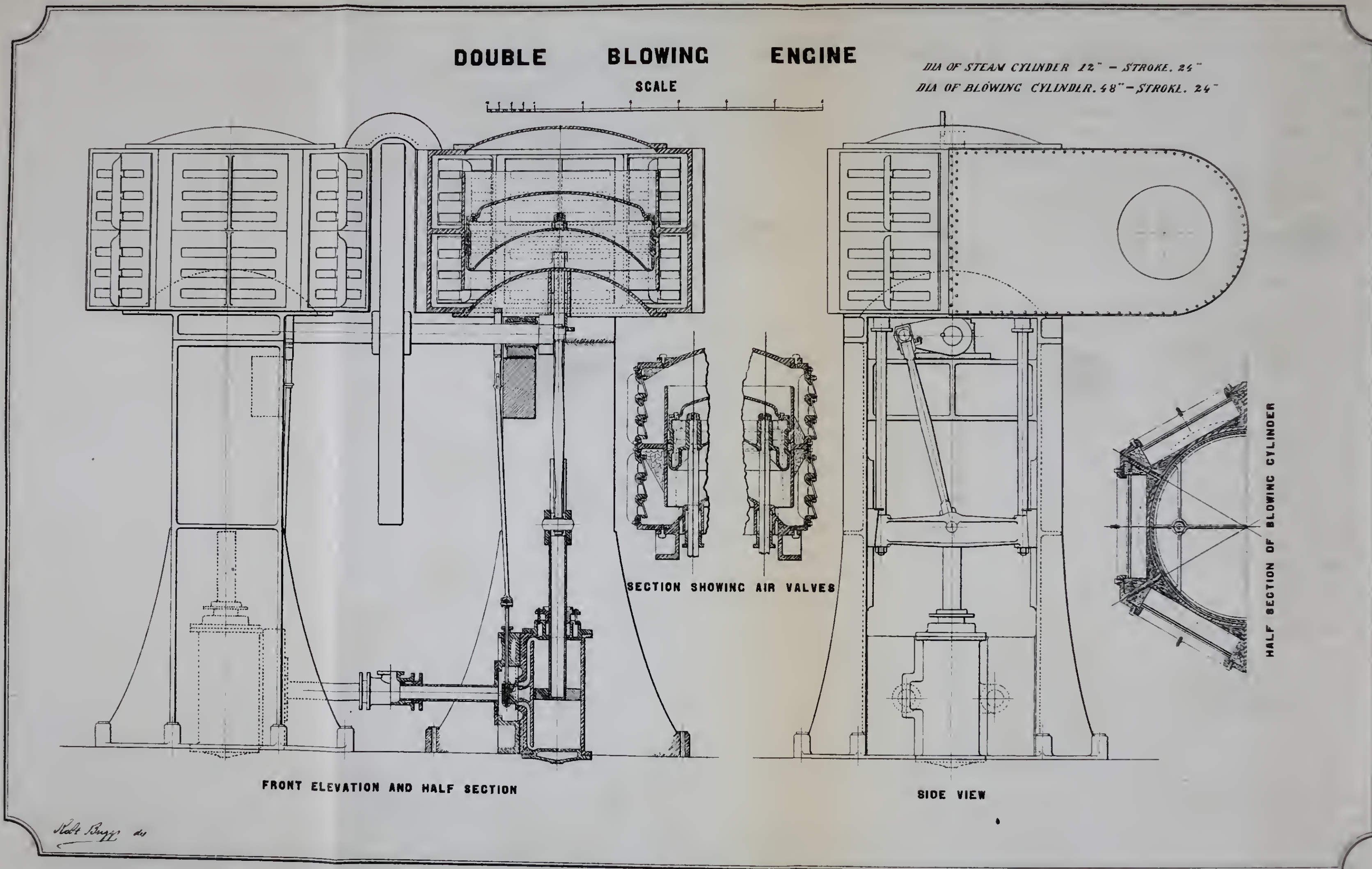
The warping of the wings, $O\ L$, is obtained by the mobility of the wing and of the little fingers, $M\ N$, supporting them on the large rods, $O\ M\ L$, which do not partake of this rotation. A little ligament of caoutchouc, $D\ B$, connects the posterior interior angles of the wings with the middle of the central rod of the machine. This ligament, whose function is similar to that of the posterior paws of the bat, plays the part of an elastic sheet to our wing, so closely resembling the topsail of a schooner. The torsions of the wing are thus automatically regulated, as required, by the combined action of the pressure of the air and of this elastic ligament. The interior third of the surface of the wing acts like a kite during the elevation as well as during the depression of the wing. The external two-thirds, corresponding to the primary and secondary quills of birds, propel and sustain the machine during the downward motions of its wings. The little drawing in the corner shows the wings just about to begin their downward beat. During the elevation of the wing the terminal feathers conform to the sinusoidal track along which they progress in the air; it thus only cuts the atmosphere without acting against it. To start the machine, we simply abandon it to itself in the air.

This machine was exhibited before the Society of Aerial Navigation on the 2d of June, 1872, and flew several times more than seven meters—the length of the public hall—raising itself in a continuous manner, with an accelerated velocity, along a line of flight inclined 15° to 20°. In an open space, the artificial bird flew over twelve to fifteen meters, elevating itself during this flight to about two meters. Another model, exhibited before the same society in October, 1874, flew in a horizontal line, vertically upward, and also ascended obliquely.

On the 27th of last November, at a public exhibition, this model flew from one end to the other of the hall of the Horticultural Society (*see Aéronaute*, February, 1875). On the 2d of July, 1875, it performed with success before the French Physical Society. The velocity of its flight is from five to seven meters per second.

The birds of twisted caoutchouc have been a great success.

M. Hureau de Villeneuve, whose zeal in the study of aerial navigation is well known, and who in his many contributions to the theory of flight since 1868 has discussed the inclination to the horizon of the axes of the scapulo-humeral articulations and their posterior conver-


DOUBLE BLOWING ENGINE
SCALE
DIA OF STEAM CYLINDER 12" – STROKE. 24"
DIA OF BLOWING CYLINDER. 48" – STROKE. 24"
SECTION SHOWING AIR VALVES
HALF SECTION OF BLOWING CYLINDER
FRONT ELEVATION AND HALF SECTION
SIDE VIEW

gence, exhibited, on the 20th of June, 1872, a bird moved by twisted caoutchouc, which, he states, elevated itself vertically to a height of nearly one meter. Continuing his researches with perseverance, he again exhibited his apparatus before the Society of Aerial Navigation on the 13th of January, 1875, after having supplied it with wings similar to those of my bird, and after having adopted several of the peculiarities which had made my machine successful. He then succeeded in giving sustained flight to his machine, which we have ourselves seen fly horizontally nearly seven meters, after having been started by a slight impulse from the hand. M. Tatin, also, in 1874, made two very curious artificial birds, using twisted caoutchouc as a motor. M. Marey has told us that he saw the first named fly in his garden, last November, from eight to ten meters. We have seen the second, nearly identical with our bird, fly in a still more satisfactory manner.

DOUBLE BLOWING ENGINE.

By Robert Briggs, Civil Engineer.

The engine shown on the accompanying plate was designed and constructed at the Southwark Foundry, of Philadelphia, 1873. It was put in use at the foundry for running one or both of two cupolas of the Mackenzie type, in substitution for two rotary pressure blowers of previous existence, which had been found somewhat inefficient in service, from original want of size and inadequate belt power. Probably so much elaboration would not have been expended upon the supply of blast to cupolas for iron founding, if it had not been determined to make the engine in every way suitable for the continuous service of cupolas at a Bessemer works, and also to exhibit the feasibility of extension of the system to blowing charcoal blast furnaces, or even to the larger (mineral) coal blast furnaces, used in the manufacture of iron from the ore. The result of the experiment, however, showed that the expenditure of money in the construction of these engines was amply warranted by the certainty of the action, the reduction of cost for wear of the machines or driving parts, and by the gain in expenditure for steam demanded to perform, more satisfactorily, more work than the pressure blowers formerly required, and as pressure blowers, when the requirement of blast is above a half pound per square inch,

were and are 15 to 20 per cent. more economical than centrifugal fans, the system of blowing by *tubs* would appear to be more profitable than any other. This last fact is generally admitted by all foundrymen where the quantity of iron to be poured daily, or at a time, is very considerable. The usual practice of direct steam blowing tubs has (in America at least) been a horizontal arrangement; in which the weight of the pistons, both steam and air, has occasioned a rapid impairment of the cylinders, demanding, commonly, a reboring of one or both after each two or three years' service. The attempt to support the piston of a horizontal cylinder (especially the air piston) by the piston rod, which in such cases is extended through the back head, has proved an utter failure, with or without the back cross head; and the common practice has been to run a horizontal blowing engine, with its leakages at the pistons, until the full pressure of steam available to drive the machine fails to give an adequate blast, when reparation becomes inevitable. The last portion of the time of running, therefore, is attended with great loss of effect and consequent increase of cost.

These conditions of wear attach also to the horizontal blowing engine for blast furnaces, which was, prior to 1848, in almost exclusive use in this country: our practice at that time having been a high pressure, direct acting one, in contradistinction to the beam engine of Smeaton or Watt, which formed and still forms the common type in Great Britain and on the continent. In 1847, the writer designed three arrangements of vertical blowing engines, with fly-wheel shaft below; one with tub above and cylinder below, and one head cross head and two fly wheels; the second with same disposition, but with intermediate cross head, and also with two fly wheels; and the third, with intermediate cross head, with cross tail, and one fly wheel. The third style of these engines was introduced by Mr. Wm. Firmstone, at the Glendon furnace, Easton, in 1848, and has continued in use to this time. Others like the first and second styles were built within two or three years of the same time by Messrs. I. P. Morris & Co., Port Richmond Iron Works, Philadelphia, (who also were builders of the engine for Glendon furnace). Since this time, this type of engine has met increasing favor, and it may now be said to predominate in American blast furnace use. The proportions of the first designed blowing cylinders were an equality of diameter with stroke, and until English practice had shown the superiority of stiffness of framing and in steadiness of work, proceeding from a shorter stroke, these

proportions were followed; but more recently, within the past four or five years numerous short stroke (*i. e.*, a little less than two of stroke to one of diameter) engines have been built and put in operation. The writer is of opinion that there were vertical engines in the neighborhood of Liege, Belgium, built prior to 1847, but upon this point he is not positively informed. It is certain that there was a vertical engine without fly wheel at Seraing prior to 1851, as described by Valerius.*

Returning to the consideration of the engine at the Southwark foundry, it will be noticed that the arrangement of inlet and outlet valves was taken from the practice of John Gjers,† but in other respects the disposition of the several parts of the machine is thought to be different from any previously proposed. It will be seen from the plate that the arrangement consists of two separate vertical engines, connected to one shaft with a single fly wheel. In each of the engines' the steam cylinder casting was placed between two upright side frames, joining them together at the bottom, and the lower head of the blowing tub rested upon, and was attached to, the top of these frames. A wide cross head received the piston rod of the steam piston in its centre, and the two piston rods of the blowing piston were joined to cross head at such distances apart as would allow the crank to rotate between them. The bottom head of the blowing tub was hollowed upwards to allow the crank to pass over its upper centre, and bring down the entire height of the engine to the least practical limit. These two engines were in every respect independent from each other, except the coupling by the same shaft, and except also a small yoke or bridge over the fly wheel, which will be noticed on the plate. The last, however, was not essential in working, but only convenient in construction and especially in erection. A foundation of brickwork, consisting of two 18 inch (2 brick) walls of 3 ft. depth (to solid original ground), and about 8½ ft. each in length, served to carry the engines and for the securing of the foundation bolts. For the maintenance of stability of the double engine when at work, even this foundation was uncalled for, nor was the yoke connecting piece necessary, for it was found upon trial in the erecting shop of the Southwark foundry, where it stood, not fastened to a plank floor, upon stake wedges and

* Fabrication de la fonte, Brussels, 1851.

† See JOURNAL OF THE FRANKLIN INSTITUTE, present volume, page 19.

leveling shims of iron; that the speed of 110 revolutions per minute was attainable without vibration of moment, and without apparent tendency to move from its loose supports. The steam required to produce this rate of motion was supplied by a two in. wrought iron pipe about 100 feet in length, through numerous elbows, from a boiler carrying 45 to 60 lbs. per square inch, and the air escaping from the cylinder gave about $\frac{3}{4}$ to 1 lb. per square inch. The subsequent use of the engine when in work at 60 to 70 strokes per minute, with 0·8 lbs. pressure, exhibited the same freedom from disturbance and exemption from vibratory movement.

The steam cylinders of this double engine were 12 inches diameter by 24 inches stroke, with a solid piston and three Ramsbottom rings of 5-16 square steel for packing. The result of service in these packings has been to show a duration in continuous daily use, accompanied with unexceptionable tightness, of about 18 to 24 months; or in such cases as this one, where the use was about four hours per day, about twice as long time. The plain slide valves had a broad lap to cut off at $\frac{5}{8}$ the stroke, with a good *negative* lead and ample cover to the exhaust, *ensuring* quiet rotation, notwithstanding the expenditure of the expansive force of the air in the tub upon the crank, which occurs after passing the centres and before the entrance of air into the tubs on the return strokes. The steam piston *rods* were made of a common $4\frac{1}{2}$ in. wrought iron tube, $\frac{1}{4}$ of an inch in thickness, which was screwed into the piston with a taper thread upon the *rod* of 1 to 32 on each side, the thread being a **V** of $\frac{1}{8}$ an inch pitch. The lower or bottom end of the rods (tubes) had a head welded in, and the upper end covers to keep out dirt. These dimensions of piston rods gave an approximate balance of steam pressure on the under side of the pistons against the weight of the reciprocating parts—both the pistons with all rods, the cross heads, connections and cranks—so that with the coupling of the pair of engines at right angles, no balancing on the fly wheels or by crank balances was required. The cross heads were cast iron, of considerable depth but of great lightness.

The blowing cylinders were 48 inches diameter by 24 inches stroke, with hollow cast iron pistons, having cast iron covers, or followers, as they might be called. The packing rings were two of Ramsbottom's, of cast iron, 2 inches by $\frac{1}{2}$ an inch section, held out by leather backing strips placed behind them in the grooves, the leather being $1\frac{7}{8}$ inches wide to allow the elasticity of form to be brought into

action. The blowing tubs seemed to work with tightness for two years of service, but no examination was made to see what wear had occurred at that time. The valve arrangement, as has been stated, was borrowed from Mr. Gjers, but it was evident that the area was much in excess of the necessities of supply or delivery of air. The motion of the valves on the supply side was exceedingly small as a whole, but a singular distribution of wide opening took place at the fullest speeds. Out of the nine inlet valves on one end of one cylinder, not over five or six would move perceptibly (except on close inspection), while 1, 2 or 3 would open quite wide, but it would not be the same one or more on the next stroke ; on the contrary, a valve which did not lift at all on one stroke might move next time to a wide opening. The conclusion apparent seemed to be that while the whole periphery of a blowing cylinder might be needed for the valves of cylinders of eight feet stroke, two-thirds of that periphery would suffice with the four foot example here given. Double leather valves of the sizes assumed, proved too stiff and refused to close tight, so that the air delivery became insufficient and a very high temperature of air in the cylinder resulted. Single leather valves with additional cross bars overcame all difficulties, and repeated examination showed that the valves closed with tightness, and opened without resistance. No sign of wear of the leather valves was exhibited after nearly two years' service. Prepared black lead with a small amount of sperm oil was the occasional lubricant of the blowing cylinders. The valves were well filled with dubbing at starting, and did not harden.

A governor working a throttle valve was attached to the engines at first; the Huntoon governor, which possessed the nominal advantage of possible alteration of rate of speed while running, was tried, but it was found that the engines run irregularly with pulsations of 10 or 15 strokes of length in accelerating and retarding velocities. The governor was then removed, and it appeared that the labor of the engine increased so rapidly with the quantity of air delivered (the pressure augmenting) that there could be no fear of its running away from any practical cause, and the speed thereafter was controlled with the main steam valve by the attendant of the cupolas.

As a matter of some interest, the loss of performance (not efficiency) arising from the clearance in the air cylinder, was investigated. Owing to the difficulties of measurement of the corners, the valve boxes or mouths were filled with water (after the wooden filling pieces for waste spaces were in) from a weighed vessel.

Weight of water in one partition of inlet in *cubic feet*,	.	0·98
Measurement of remainder of same partition "	.	0·57
Weight of water in one partition of outlet "	.	0·56
Measurement of remainder of same partition "	.	0·54 2·45
For three partitions . . . "	.	7·35
Add a half inch clearance of piston, "	.	0·52
Total clearances at each end of cylinder, "	.	7·87

As the area of the cylinder equals 12·56 sq. feet, the displacement of a stroke equals 25·12 cubic feet, and it follows that these clearances of 7·87 cubic feet are equivalent to 5-16ths (0·3125) the displacement of the piston, or $7\frac{1}{2}$ inches of the length of the stroke. Assume: *Pressure of blast at lbs. per square inch,*

1 2 5 10 15 20 25

Then the total pressure upon the air enclosed in the clearances becomes in each case equal to these plus 14·7 lbs., and the $7\frac{1}{2}$ inches upon the area of the piston will expand before the atmospheric pressure is reached, and the inlet valves can begin to open

$$\frac{1}{14\cdot7} \quad \frac{2}{14\cdot7} \quad \frac{5}{14\cdot7} \quad \frac{10}{14\cdot7} \quad \frac{15}{14\cdot7} \quad \frac{20}{14\cdot7} \quad \frac{25}{14\cdot7}$$

or in inches of length of stroke,

0·51 1·02 2·55 5·10 7·65 10·2 12·75

and, in place of 24 inches or the whole stroke, the effective length of stroke becomes, *in inches of length of stroke,*

23·49 22·98 21·45 18·90 16·35 13·80 11·25

and the volume of air at atmospheric pressure, taken into the air cylinders at each double stroke of the pair of engines, becomes, *in cubic feet per revolution of fly wheel,*

98·21 96·14 89·66 79·00 68·34 57·68 45·02

as the total displacement of the air pistons would be 100·48 cubic feet, the proportion of performance to displacement will be easily seen to be almost in decimals as given in the last line of figures.

There is, of course, no loss of useful effect in this loss of performance or capacity, except what proceeds from friction of parts of the engine as a whole, (or in possibly some complicated phenomena of transformation of force to heat); for the same force which is expended in the compression of the volume of air left at the end of the stroke in the clearances (which it has been shown equals $7\frac{1}{2}$ inches of stroke) is given back in impulse to the engine by expansion on the return stroke. Of course, this statement overlooks the resistance of the valves and the leakages, for which it may be presumed a fur

ther allowance of 5 to 10 per cent. of the capacity of the air cylinder as a whole can be admitted as loss in actual performance. Whence it would appear that with 25 lbs. pressure of air blast (above the atmosphere), blowing engines with valves, valve spaces and total clearances, as shown in this example, would deliver less than half the quantity of air due to the displacement of the air pistons, while at 2 lbs. pressure, they would deliver about nine-tenths of the same displacement. If the supposed blowing engine to give 25 lbs. were to have (as appeared from observation of this example to be sufficient) but two-thirds the number of valves, and the valve passages be proportionally reduced in size; the ratio of delivery to displacement would thus (under 25 lbs. pressure) be increased from 45 to 56 per cent. This supposition of 25 lbs. pressure requirement is obviously in great excess, and at the practical pressure for a blast furnace of 10 lbs., the air delivery of these blowing engines approximates towards 80 per cent. of the capacity of the air cylinders.

INDICATOR DIAGRAMS.
DOUBLE BLOWING ENGINE.
Speed 60 Revolutions.

The accompanying pair of diagrams will illustrate the performance of the engine on regular work in the middle of a heat (of three or three and a half hours) before the charge in the cupola had become very heavy. At the time of taking these cards, the pressure of steam, as given by a pressure gauge at the boilers, one hundred feet distant from the blowing engine, was 56 lbs., and at the water separating reservoir (6 feet long of 12-in. vertical pipe), about twelve feet from the engine, at least 48 to 50 lbs.; and it was consequently necessary to throttle the steam by the main steam valve to give the 26 lbs. maximum steam pressure indicated on the cards. As no considerable steam supply chamber existed in the pipes and steam chests between the main valve and the slide valve faces, the effect of the throttling upon the top line of the indication, when both cylinders were receiving steam simultaneously, is marked. The steam pressure will be seen to

have equaled 17·8 lbs. on the average, and the air pressure 0·8 lbs., giving the entire useful effect of the steam of 72 per cent. to the passage of the delivery valves, all frictions of engine being included. This ratio of useful effect would increase with an increase of pressures. At and below a half pound pressure per square inch, the centrifugal fan becomes the more economic machine, the ratios of economy of the fan over any other means of moving air increasing rapidly as the pressures fall below twelve inches of water column; above this pressure the rivalry is between the reciprocating and the rotary engine, and at the present time the rotary engine, either as a motor or as an appliance of force, seems scarcely to have equaled the reciprocating one.

The proportions of the steam to the blowing cylinder, one to sixteen, in this instance gave the definite ultimatum to the pressures. The steam was supplied by a four inch pipe of about 100 feet length, but well coated for protection from loss of heat, from boilers usually carrying 60 lbs. pressure; some other demands were supplied by the same pipe, so that the final supply at the engine could not be taken to exceed 48 to 50 lbs. pressure, and with the cut off and cushion of the valve, the average maximum pressure would become about 40 to 45 lbs., thus giving a possible pressure of air blast of from $2\frac{1}{4}$ to $2\frac{1}{2}$ pounds only. While, however, these proportions controlled pressure of blast to this limit, it was perfectly feasible to have made the steam cylinders of any required diameter, and at 2 ft. diameter this little engine would have possessed the power needed for running a blast furnace at usual pressures for anthracite coal, that is, up to 10 lbs. pressure of blast per square inch. Such an engine running at the moderate piston speed of 320 feet per minute, or 8 revolutions, would give 7000 cubic feet of air in that time, and represents the average demand for the production of 30 tons of pig metal in 24 hours. The requirements of the most recent practice in iron making are much larger in quantity, but it has been demonstrated that these engines run with quietness at much higher speeds than 80 revolutions (120 revolutions having frequently been attained), and there can be no objection to the use of several engines, as many may be desired to supply a quantity demanded, while there are many advantages which would follow such use. For the cupola, or for the light blast of the light burden of a charcoal furnace, the type of engine now described offers, in simplicity of construction, in steadiness of blast, in probable duration and exemption from accident, in room occupied, and in original cost, many palpable advantages.

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.†

[Continued from Vol. lxxi, page 126.]

The calculations which Helmholtz‡ has lately put forward, concerning the respective ratio of bulk to resistance and to speed in ships and balloons, are, therefore, of great value. According to him, the speed of Dupuy's balloon nearly attained the maximum possible for its size. In order to proceed slowly against a fresh breeze, with the sources of mechanical power at present available, the volume of the balloon must be three and a half times larger than that of the largest ship of the line. This demands of the tissue with which the balloon is to be constructed, a degree of strength scarcely possible. In fact, the expectations of the inventors did not go beyond the hope of steering the balloon when the air is tranquil. If the screws and paddle wheels are enlarged, they must also be made thicker or stronger in order to preserve the necessary firmness. "We can only work sparingly with slow-moving propellers of large surface, and to produce these of the requisite size without burdening the balloon too much, will constitute one of the greatest practical difficulties."

With this sentence, Helmholtz concludes his memoir, and the prospects to which he points fall very far short of the enthusiastic prophecies of such as are guided by their wishes rather than by sober scientific considerations.

The problem of steering balloons turns on three conditions—the

* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† From the *Chemical News.*

‡ Helmholtz, *Berl. Akad. Ber.*, 1873, 501.

production of balloons of the lowest specific gravity ; the construction of propellers, light, but capable of resistance ; and of sources of power at once light and capable of performing a high duty. In how far chemistry has prepared the way towards the fulfillment of the last condition, *e. g.*, by means of aluminium, the future must decide. The first condition she has accomplished ninety years ago, by means of hydrogen, as is now fully recognized.

[On the evidence of these documents the procedures for illumination with hydrogen hitherto employed must be condemned, if anything further is desired than the display of objects and transparencies for the lecture room or the stage.

Hydrogen lighting was not represented at the Vienna Exhibition —a further indirect evidence that it had not found any wider application.

An objection, long known, depends on the high coefficient of diffusion of hydrogen, and its consequent ready escape through the pores and fine chinks of the mains, a circumstance the more dangerous, as hydrogen is not, like coal-gas, at once detected by its odor. The diffusion coefficients of gases, according to Graham's experiments, are inversely as the square roots of their specific gravities.

But if lightness is a disadvantage for the delivery of hydrogen through pipes, we have now to consider the advantages springing from the same attribute. In November, 1872, a dream long cherished seemed on the point of fulfillment. The brothers Etienne and Joseph Montgolfier sent up the first balloon at Avignon by means of hot air.*

With natural enthusiasm the populace of Annonay applauded them when, on June 4, they repeated the experiment of the previous year on a larger scale, and king, court, and capital congratulated the inventors when they repeated it soon afterwards at Versailles. The dominion of the air seemed won for mankind, to whom space had now no limits. To-day we look back upon the invention with a cooler glance, as, in spite of the lapse of ninety years, it has remained in its infancy. We are still unable to speak of aerial navigation, since the balloon, incapable of being steered, has remained the plaything of the air instead of becoming its ruler. One step, indeed, towards

* The historical details concerning aeronautics, where no other authorities are given, are taken from the excellent summary of Louis Figuier in *Merveilles de la Science*, ii, 426–626. See also Marion, "Les Ballons," Paris, 1867 ; and Fonvielle, "La Science en Ballon," Paris, 1869.

the desired end was taken when Charles, Professor of Physics at the Conservatoire des Arts et Métiers, at Paris, substituted hydrogen for the heated air in the balloon. On August 27, 1783, Charles, in concert with the Brothers Robert, skillful mechanicians, accomplished the ascent of the first hydrogen balloon in the Champs-Elysées, his invention being known as the Charliere in contradistinction to the Montgolfiere. Both systems were used for the first aerial voyage, the one in November, and the other in December, of the same year. Previously, the balloons had been sent up empty, or only tenanted by some animal. The first aerial navigator, Pilâtre de Rozieres, conceived the idea of combining both systems, which was the occasion of his death. The fire in the Mongolfiere was communicated to the hydrogen in the Charliere, and on June 15, 1785, balloon and aeronaut fell shattered on the limestone rocks of the coast, near Boulogne.

The motive for this unfortunate combination was the wish to raise or lower the balloon by stirring up or extinguishing the fire—a plan which makes ballast superfluous, and which has been revived in a recent essay* by Captain Gaede (of the Military School at Hanover), and with due precautions would be doubtless practicable. Since the time of Pilâtre de Rozieres, 3700 balloon ascents have been undertaken, and only sixteen fatal accidents have been heard of,† due chiefly to Montgolfieres, though the sea has been repeatedly crossed by aeronauts. Not long after the discovery of balloons, they were used both for practical and for scientific purposes. Coutelle used them for military reconnoitering, and according to Carnot's testimony, contributed essentially to the result of the battle of Fleurus. On the other hand, Captain Gaede considers the results attained by means of balloons, especially in reconnoitering fortified places, both in earlier campaigns and in the Franco-Prussian war of 1870–71, as insignificant. Napoleon I. regarded the military efficiency of the balloons of his time not more favorably. After his return from Egypt—where the attempt to convince the natives of the superiority of Europeans by means of a balloon ascent had failed, owing to their fatalistic indolence—he closed the military aerostatic school which

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*Gaede, "Ueber den Bau Gefesselter und Lenkbarer Luftschiffe." Berlin: Mittler, 1873.

†Stephan, "Weltpost und Luftschiffahrt. Berlin: 1874.

had been founded at Meudon, under the management of Coutelle and Conti, evidently holding its military results as unimportant.]*

Upon the consideration of hydrogen and oxygen should follow an account of the industrial applications of water. These, however, are so many-sided—not to say omnipresent—that they escape our reach. The most important will be considered in special chapters.

The elements, oxygen and hydrogen, form, however, as is well known, a second compound, peroxide of hydrogen, H_2O_2, which has latterly begun to acquire a certain industrial importance.

Peroxide of Hydrogen.

In 1818, Thénard caused acids to react upon barium peroxide, and obtained solutions extremely rich in oxygen, which they gave up with remarkable ease. He considered them as higher grades of oxidation of the acids employed, but soon perceived their true nature.

His method of preparation, which is still in use, is as follows: A known amount of concentrated hydrochloric acid is diluted in a beaker with 8 to 10 volumes of water, and exposed to a freezing mixture. A quantity of barium peroxide, somewhat less than sufficient to neutralize the acid, and as free as possible from other oxides (especially from manganic oxide, which would decrease the yield), is ground up to a fine pulp with water, and gradually added to the acid, in which it should dissolve without effervescence. Dilute sulphuric acid is then cautiously added, in order to throw down the dissolved baryta as sulphate and liberate hydrochloric acid, which then serves to react upon a further quantity of baric peroxide. After the liquid has been filtered off from the barium sulphate, a new dose of pulpy barium peroxide is added, and the above described process is several times repeated. After the sixth or seventh addition, the liquid contains a sufficient amount of the peroxide of hydrogen. If perfect freedom from acids is required, it is successively treated with sulphate of silver and hydrate of barium. The filtrate is concentrated over sulphuric acid in a vacuum.

Pelouze adds a paste of barium peroxide to a solution of hydrofluosilicic acid, and filters the solution of peroxide of hydrogen from the fluosilicate of barium.

Dupré† and Balard use a solution of carbonic acid in water for the

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* Erratum.—That portion of this paper which is included by brackets should have been printed in the article, page 123, following "Society," and before "Ballooning."

† Dupré, *Comptes Rendus*, lv, 736 and 758.

same purpose, adding gradually very small quantities of finely pulverized peroxide of barium.

Recently J. Thomsen has proposed the following modification of Thénard's process* :—Finely ground peroxide of barium, or the commercial so-called hydrate, is dissolved by addition to dilute hydrochloric acid, till the latter is almost neutralized. To the filtered and cooled solution so much baryta-water is then added, that foreign oxides and silica are thrown down, and a slight precipitate of barium peroxide is formed. The solution is then filtered and mixed with a sufficient quantity of concentrated baryta-water, whereby, as was shown by Brodie,† crystalline hydrated peroxide of barium is deposited. The precipitate is filtered and washed till it no longer shows the reaction of hydrochloric acid. The hydrate thus obtained can be preserved for a long time in closed vessels in the moist state. To obtain peroxide of hydrogen it is added, with stirring, to dilute sulphuric acid. The concentration of the latter may reach 1 part of acid in 5 parts of water. When the solution shows only a very faint acid reaction the sulphate of baryta is allowed to settle and the liquid is filtered.

(To be continued.)

VARIETIES OF THE SUGAR CANE.

Mr. H. Prestoe, the colonial botanist of Trinidad, has recently published an official report, describing the fourteen best varieties of sugar cane, among thirty-two surviving kinds of a larger number sent from the Mauritius, and stating the conditions (twenty-five cents for a stout plant or tuft, or in joints at twenty-five cents for every five), at which planters can obtain any of those that are ready for cutting and planting. Eighteen of the thirty-two seem to be distinct varieties, and deserving of care and cultivation, as possessing characters that give them, in one way or other, a superiority over the two or three sorts at present in cultivation, and among which the yellow Otaheite takes by far the largest place. Some of the new varieties are peculiar for length of joint (properly *internode*, or 'tween joints), and some for length of joint united with stoutness. One is remarkable for both, joined with a very soft tissue. This sort is of a fine, dark, claret color, and is numbered 10 in the list. In common with many of the others, it

* Thomsen, *Ber. Chem. Ges.*, 7, 74.

† *Pog. Ann.*, cxxi, 372.

also bears drought well and is prolific. Two (Nos. 13 and 14), being extremely hardy and prolific, are recommended as fodder canes, to plant on poor, dry soils, unsuited for the better canes. They are much hardier than Guinea grass, and will yield a manifold greater weight per acre of surpassingly nutritious fodder. They are purple-striped. No. 8 much resembles the best yellow Otaheite. No. 11, a dark purple cane, perhaps a less luxurious offshoot of same parent as No. 10, is also soft in tissue. All to No. 12 are described as stouter, more promising canes than the Otaheite, planted in the same soil at the Garden, and under the same conditions, and which were rarely $1\frac{1}{2}$ inches in diameter. Only No. 4 was so small, Nos. 2, 6, 9, 11, and 12 being $1\frac{3}{4}$ inches, Nos. 1, 3, 5, and 7 being 2 inches, while the joints of the very handsome, clean cane, No. 10, averaged $2\frac{1}{2}$ inches in diameter by $6\frac{1}{2}$ inches long. No. 5 has 6 inch joints, No. 9, $5\frac{1}{2}$ inches, and Nos. 4, 6, 11, and 12 have 5 inch joints. Those of No. 1 are $4\frac{1}{2}$ inches, of No. 3, 4 inches, and of Nos. 2 and 7, $3\frac{1}{2}$ inches. The joints of Nos. 8, 13, and 14 are undescribed. No. 6 grows very straight canes. No. 7 retained a green foliage, and although short in joint, is stated to have a very fine habit. The botanist is careful to say that, having grown on poor soil, the dimensions given indicate not the ultimate standard these varieties will attain to under more favorable conditions, but only their relative value compared with the common Otaheite, in fields planted alongside of them. He anticipates that a richer and moister soil will improve all. Purple and purple-striped canes are generally admitted to be preferentially adapted, by the hardiness of their habit, to the poorer, drier soils; but, it must be remembered, they have a hardness of tissue that gives more trouble in crushing. Nos. 10 and 11, however, are remarkable exceptions, and he thinks that others of the list, when tried in really good soil, will improve, and assume a freer habit, and gain a larger size than ever shown by our old friend, the yellow Otaheite. There are green canes in the Botanic Garden, possessing characters thought peculiar to purple canes. The paper mentions incidentally a grand purple cane obtained from the islands of the South Western Pacific, the "Queen" cane, whose joints are 4 or 5 inches in diameter. It will take a few years to establish a good supply of any favorite variety. Experiments in shortness of time to ripen, gallons of liquor per acre, saccharine strength per polariscope, and other particulars are also required before the planter can know the relative value of the different

kinds. There is not the least reason to doubt that with selection and good nursing, very superior and fixed qualities can be obtained in sugar cane, as freely as they have been in wheat, turnips, beet, fruit, garden flowers, and domestic stock. Tropical staples are ages behind Europe in this respect, and have hence grand possibilities *in ovo*, but they will not be realized without effort, judgment, and perseverance. According to the *West Indian*, a Barbadoes paper, a foot in length of sugar cane grown in that island weighs $\frac{3}{4}$ of a pound, and a bunch of canes grown in one hole weighs 54 pounds on an average, which yield 4 gallons of liquor or juice, from which 4 pounds of muscovado sugar are got. Of the 54 pounds, the juice weighs 50 pounds. An acre of ripe canes, planted six by five feet, gives 1452 bunches, or 5808 gallons of juice, or 5808 pounds of sugar. At 50 pounds of cane to the hole (or hill) an acre of canes, planted as above, would weigh, when cut, 72,600 pounds, or 36 tons, 90 per cent. being juice. It takes these 36 tons of cane to give $2\frac{1}{2}$ tons of raw sugar, or 360 tons, from a 10 acre field, to yield 25 tons of sugar. For the first six months the plant requires but little rain to keep it in vigor; but afterwards in needs a constant supply and an increase of growth in the last three months of the year.

ANALYSIS OF "TELL-TALE SUGAR LIQUOR" FROM THE SAFES OF TWO VACUUM SUGAR PANS.

By G. C. Stewart, F. C. S., Chemist at the Cappielow Sugar Refinery, near Greenock.

All vacuum sugar pans (exceptional instances overlooked) are furnished with "tell-tale sugar liquor" safes for catching any "sugar liquor," etc., which might accidentally or peradventure "otherwise" boil over during the evaporating process in sugar refining.

These safes yield, when emptied, solutions which may vary in chemical composition according to a great variety of circumstances. First of all, the mechanical construction of the pans may have a great deal to do with this, as has also the position in which the safe itself is fixed. If the pan is low set and very short in the swan's neck, ten to one but that the "liquor" drawn from the safe of such

a pan will be found upon analysis to be much richer in "sugar" and other organic matter than the "liquor" drawn from another pan high set and very lofty in the swan's neck.

Such is the case, and occasionally in sugar boiling, when too much "salt" water is given to the condenser during the evaporating process, it not unfrequently happens that this excess of salt water finds exit by "more roads than down the Torricellian tube."

When such an accident occurs, the "liquor" drawn from the safe will be found upon analysis to be almost "salt water," and will actually taste salt.

By keeping up a continual examination of the "liquors" drawn from these safes day after day, a good idea will be formed by the chemist in charge of the sugar refinery as to how the pans are being handled by the pan men.

The following two analyses of this "liquor" will be examined with curiosity by your numerous readers who take a direct interest in the literature of the subject.

100 parts by weight contain :—

	No. 1. Per cent.	No. 2. Per cent.
Crystallizable sugar,	4·80	11·43
Fruit sugar,	3·37	4·52
Extractive organic matter,	1·76	1·54
Insoluble matter,	0·56	0·08
Soluble salts,	2·57	0·90
Iron,	0·26	0·45
Copper,	0·21	0·05
Water,	86·47	81·03
	100·00	100·00

No. 1.—This "sugar liquor" is from the safe of a modern vacuum sugar pan recently constructed, high in the swan's neck, and of artistic mechanical design.

No. 2.—Is the same "liquor" drawn from the safe of an old fashioned vacuum sugar pan, low set, short in the swan's neck, and as old as Howard.

Pumping Engine for the Water Works at Hull, England. A new Cornish pumping engine was started at this place on the 28th of December, 1875. This engine is one of the largest of the kind yet constructed, having a 90-in. cylinder, with a stroke of 11 feet, and presents, especially in the pumping arrangements, several peculiarities. The *Engineer* (London) promises illustrations of the machine at an early impression, merely making the chronicle of the start with the statement that it was in every respect successful.

JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

The Use of Steam Carriages on the Street Railways and Common Roads.—In none of the appliances of the steam engine, since it was emancipated from the patents and the practice of James Watt, in the year 1800, has so little accomplishment resulted from so much ingenuity and effort, as has been expended upon the use of steam as a means of transport in the ordinary avocations of life. The very earliest attempts at locomotion were made upon common roads, and so far as *movement on these* has been effected, the success attained nearly seventy years since by Trevithic has scarcely been equaled, and certainly has not been far surpassed down to the present time, notwithstanding the great advance in the knowledge of the properties of steam, and in the facilities for construction. The essays have numbered by the hundreds. Experienced mechanics, with skilled labor applied in the direction of thorough knowledge of mechanism and of the

steam engine, have vied with inventive projectors who have possessed that ignorance, which, untrammeled by *educated* notions to unlearn, sometimes gives scope to ingenuity and novelty; and both knowledge and invention have failed alike.

Within the past few years there has been put in use in England, as a means of hauling heavy weights, the form of engine known as a Traction Engine, and as the roads of that land are (and from the absence of frost can be) kept in excellent order, and as the quantity of heavy material to be removed is very great, these engines have increased, and still continue to increase, in number. Another class of engine in England, but little known in the United States, the Agricultural Engine, which is a power engine of small size, with its boiler mounted on wheels, to be moved from place to place, has also been made to be self-propelling. The Road Roller is another type of locomotive which has been quite fully introduced. None of these answer the description of steam carriages, nor does the kind of engine likely to grow from them, promise much towards a Darwinian development into what will eventually be found to be employed in transporting passengers and light loads in the street, whether on the rails or on the pavement.

The mechanical difficulties to the application of steam as a motive power for carriages, have gradually come to be appreciated, and with the somewhat more complete knowledge of the conditions and requirements, it is probable that the next attempts, made in earnest, by skilled and informed mechanics, will effect more satisfactory results. It is a settled conclusion that the adhesion of the wheels, or of a pair of them, sustaining half the load, is ample for the purpose of impulsion at any grades practicable for ordinary road use, only noticing that the contact or bearing of the drivers upon the ground must be positive and uniform. A four wheeled vehicle with axles attached to a rigid body, when standing or running on the uneven—generally twisted—surface of a road, will obviously rest or have its bearing only upon three of its wheels, and this condition of three points of bearing attaches to the tram road locomotive, as well as to the common road one. Balance bars or gimbal-hung swinging axles will secure the equal distribution of weight upon drivers, or what in the road carriages is equally essential, on directing wheels. The possibility of *driving* around any curve, as the directing wheels may lead or trail, is secured by the "jack-in-the-box motion" of the traction engine,

which applies the force to either driver of a pair of wheels, imparting to either wheel in whatever proportion is requisite, the motion or rotation it should have when running upon a curved line. Of course, the abrading action of the tires (like that of the faces of a mortar mill) upon the ground, yet remains, and the wear on them, and on the road bed at the place of turning, will still be large, but the leverage to overcome this grinding, and the amount of grinding, will be so much less, than that which accompanied the action of wheels rigidly attached to an axis, that it can be surmounted or endured. The conditions of leading the tram road carriage around the curve differ altogether from those of guiding the ordinary road carriage. The tram road carriage will guide itself, with either the Bissel two wheel truck, or, more perfectly still, with the old German six wheeled wagon arrangement, (in which the axles adjust themselves radially to any line of curvature); while the ordinary road carriage must have the swinging axle only for a guide.

In the application of power to the steam carriage, it is apparent that the starting resistance is the most difficult to overcome; and, although many methods suggest themselves, none has yet had practical application in service in parallel work. The utilization of the momentum of stopping *may* be available to help the starting of a carriage. This has already been elucidated as possible on railway trains, but in this case the gain from all the momentum lost at a stoppage bears so small a proportion to the labor of the locomotive engine, as not to be worth saving. The necessity of two speeds, at least, is acknowledged, but with the gearing of the jack-in-the-box, there is no great objection to double speed wheels in addition. The total motive power of the engine demanded is about what is rated two horse power, at the most, and the engine becomes very small. The success of the three cylinder engine, now made by the thousand, almost, in England, and its peculiar facility for the use of the expansive force of steam, at high velocities, seems to open a ray of light into the darkness where the steam carriage of the future now lays. The recognition of the fact that the interstices of a mass of coal, on a given surface, present an equal area for any size of lump, whether coarse (large) or fine, only that all the lumps or grains must be sorted to the same size, is slowly being made; and as our fine anthracite coal, of *pea* size, runs like water, it follows that automatic firing of

the small boiler will be the finality for the purpose of the steam carriage (as well as the possible finality of the firing of marine, if not all, steam boilers). This, with suitable automatic arrangement for feeding, will permit the steam carriage to be run by one man alone. Only some of the salient points of the mechanism of the coming carriage have been noticed here; others of nearly equal importance present themselves, which can be discussed or settled, in the same way, by those especially interested.

Eventually, the steam carriage will be as distinctive as the locomotive engine, and will have its nationalities as the locomotive has, and its individuality, as the American locomotive of to-day has WM. MASON inscribed upon it.

The steam carriage when in use on the public highways or tram tracks, will be much more safe from accident of any kind than the ordinary vehicle or the street car. The requirement of penalty can be made as stringent as letting all statute laws out of the question will allow the enforcement of common law; and under the impulse of such penalties—safeguards, catchers, detentors or arresters—automatic contrivances of all kinds, will multiply to the point that will give security to the other traffic, quite as great as that now attendant upon the average driver and the carriage horses. While the control of the apparatus, either to start or to stop, *can* be made certainly as effective as the present ordinary carriage, however carefully driven.

The abuse of animals (horses) in our street cars is a shocking evil, and those instincts of humanity which lead us to avoid the occasions or exhibitions of cruelty, now urge with great strength the substitution of inanimate force for so completely mechanical exertion of power. The repairs and restoration of the road ways, consequent upon the employment of horses in so large numbers, form the chief items of expense to the highway department, and the substitution of steam carriages would materially reduce this burden on the city. The removal of the horses from the street railroads alone, would greatly improve the cleanliness of streets, by the prevention of so much decomposable matter now deposited upon the surface of the pavement, to be ground under the wheels to an impalpable powder, blown about with the winds, and vitiate the very air we breathe. With due regard for the public health alone, it is desirable to substitute the steam carriage for the horse car.

Journ. of the Franklin Institute

The Massachusetts Institute of Technology.—The two papers which appeared in the Feb'y and Mar. numbers of the JOURNAL, viz.: Cotton Spinning, by F. H. Silsbee, and the Use of the Microscope in Qualitative Analysis, by F. W. Very, were theses of advanced students of this institute. An original and fundamental investigation by a competent and studious pupil into any of the common usages of mechanism, will always yield an ample store of unexplored knowledge, and allow the production of a novel and interesting paper, truly valuable to science, and suitable in all ways for publication. It is a great gratification to an editor to be offered papers like those here referred to, which, in place of being the extravagant claims of novelty and performance, are simple descriptions and investigations of actual existing facts. Even when the paper presented, is not the distorted and biased representation of the advertisement of a *scheme*, too often it is merely a study and collation of something found in a book, valueless in repeating all the errors of former collators, and in wanting any truths of original discovery. It is the province of the professor to direct the energies of the student toward such subjects as will allow him to test his book knowledge and apply his natural ability to comprehend and express the technical points which the subject presents. In none of our institutes have the practical branches of applied mechanics been taught with more success, than at the Massachusetts Institute of Technology, and these papers in the JOURNAL can be taken as evidence, not alone of the ability of the scholar, but also of the elevation of the standard of technical education which has been attained at the school. It is for the purpose of giving due credit that this notice is written, as the proper reference to the Institute was omitted in the headings of the papers.

NOTE ON FINDING THE STRENGTH OF A COLUMN OF IRREGULAR SHAPE.

By THOMAS M. CLEEMANN, C. E.

Rankine's general formula for the strength of a column fixed at the ends is:

$$P = \frac{fS}{1 + a\frac{l^2}{r^2}},$$

in which S is the cross section of the column; l is the length of the column; r is the "least radius of gyration;" f for wrought iron,

36,000, and for cast iron, 80,000; a for wrought iron, $\frac{1}{36000}$, and for cast iron, $\frac{1}{6400}$.

For columns of ordinary sections, the value of r can be found by the calculus, and its value for many such sections is given in Rankine's "Civil Engineering." It sometimes happens, however, that the cross section may be so irregular or discontinuous, that the calculus cannot be applied. It is then necessary to pursue a different method, and the following one, of obtaining the value of r by experiment, is believed to be new, and is recommended to engineers for its extreme simplicity. It is very similar to that used in Bartlett's "Mechanics," for finding the moment of inertia of a fly-wheel:

Draw the cross-section on stiff cardboard, and cut it out carefully. Make a small hole in any part near the edge, through which insert a pin, and make it oscillate about the pin like a pendulum. Count the number of oscillations in a minute. The length of the equivalent simple pendulum is given by the equation:

$$L = \frac{140796}{N^2},$$

in which N is the number of oscillations performed in a minute. The radius of gyration is then found from the equation:

$$r^2 = \tfrac{1}{2}(Le - e^2),$$

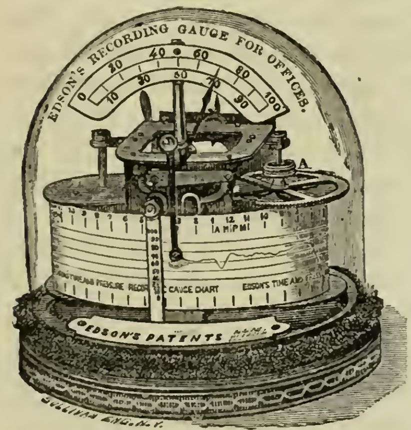
in which e is the distance from the point of suspension to the centre of gravity of the section, expressed in inches. The above is only true when the cross section can be divided symmetrically by two axes at right angles to each other. The sections of columns ordinarily used, however, such as those of the Phœnix Iron Co., and the Keystone and Kellogg Bridge Companies, conform to this condition.

In cases of great irregularity of cross section, the pin should be placed in two or three places near the outer edge, at equal distances from the centre, and the experiment of counting the oscillations repeated. The greatest value of N is the one to be used.

Edson's Time and Pressure Recording Gauge.—One of these instruments was presented and described at the meeting of the Institute in January last, and excited considerable interest.

This instrument, in its present form, consists first of a circular base piece of cast iron, carrying all the other parts. In the upper side of the base piece is a cavity, over which is placed a corrugated diaphragm

spring, about 8 inches in diameter, firmly clamped down at its periphery so as to form a steam tight joint. Into the chamber thus formed, the steam from the boiler is admitted, and raises the spring to a greater or less distance, according to the degree of pressure.



To the upper side of this spring is attached a connecting rod, which, by means of a rockshaft and arms, operates a sliding bar carrying a pencil, which is thus made to move up and down in a vertical line, as the pressure in the chamber increases or diminishes.

By means of clock work, placed in the back of the instrument, a strip of paper is made to move along the front of the instrument at a uniform rate, and in such a position that the point of the pencil shall bear against it. This strip of paper is ruled lengthwise to a scale representing the varying pressures in the boiler, and is ruled crosswise into equal spaces representing the exact space through which the paper will be moved in one hour. These cross rulings are assembled so as to form 24 equal spaces, and numbered and lettered to represent the 24 hours of the day, thus forming charts to be removed and filed away as a permanent record of each day's performance.

It is evident that if this strip of paper should have no movement, and the pressure under the spring should become sufficient to raise it and the pencil, the latter would make a simple vertical mark on the paper, and the only information its after inspection would give, would be the extreme limit to which the pressure had risen.

If, however, while the pencil is thus being moved vertically, the paper is moved horizontally at a regular rate of speed corresponding to one of the crosswise spaces in each hour, an irregular line will be marked on the paper, representing the variation of pressure, and an after inspection will show exactly what the pressure was at any moment during the time it was operating.

Thus a permanent record is made of the pressure in the boiler, which is of value to the owner or manager of any establishment using

steam, enabling him to judge of the faithfulness or ability of the fireman, and detect faults in the safety apparatus, and may also be of much benefit to the honest fireman, by pointing out errors he may have committed in the management of his fires.

On the front of the instrument is an index hand, which, by means of the proper mechanism, is moved over a segmental scale, graduated to show the pressure in the boiler at any time by inspection, as in the ordinary gauge.

The rockshaft, before mentioned, carries an arm, which can be so adjusted as to close the circuit of an electric alarm bell when the pressure shall reach the prescribed limit.

The use of this instrument is not open to the objection often urged against automatic attachments to boilers, which are designed to do by machinery that which should be done by the attendant, as this is in no wise intended to assist him or relieve him of his present duties, but simply makes an exact record by which others may know when, and to what extent, fluctuations of pressure have taken place in the past. K.

The Storage of Petroleum, Benzine, or Similar Fluids, while on Draught for Use or Sale.—The class of substances here mentioned have now become articles of common and necessary use in manufactories, and regular branches of traffic in the shops: and many accidents, with sometimes serious disaster, result from their unexpected ignition and explosion. The great danger, of course, lies in the explosive mixture of air and hydro-carbon vapor, which forms in the partially empty tanks, barrels, or containing vessels, which occasionally ignites, notwithstanding the great care that may have been exercised to prevent any access of flame to the mixture. Wherever these fluids are kept it is usual to establish strict rules about drawing them off at night, and against the proximity of any light at any time. But when it is considered that a current or stream of the mixed vapor and air will convey a spark more rapidly than a train of gunpowder, it is not to be wondered at, that every few days add to the record of coal oil explosions. Having become cognizant of the repeated explosions of a benzine storage tank at a gas-works—from flame twenty-five feet away—from a laborer's pipe entering the shed, from a plumber's furnace at a long distance; the writer advised the adoption of a plan which would effectually prevent all future accidents of this nature.

As the same plan is applicable to all tanks or vessels for storage of these fluids, the present publication is made to bring it into notice. In the case of the gas works, all that was necessary to be done, was to close the top of the tank gas-tight, and connect a pipe from the top to the gas mains.

Where the tank is to be supplied or re-filled by means of a pump, it is only needful to connect the supply pipe to it by a tight joint, but if the oil or benzine is poured in, a syphoned or sealed mouth or tube must be attached to the tank so that it can be filled, with, of course, the extra resistances of (in this case 3 inches of water pressure), and equally, of course, upon drawing out any benzine, it would be discharged under (3 inches) greater head than the height of benzine above the faucet. The result of the arrangement was to fill the space above the benzine with common gas, which may be inflammable enough to burn in air, but which is wholly inexplosive. In manufactories or shops which are lighted by gas, the same arrangement is feasible, and it is only necessary to connect the top of the closed oil or benzine to the gas pipes of the building. Where dry meters are used for measuring the supply of gas, they will register backwards the few feet of gas displaced by a fresh supply of oil or benzine, and most wet meters will also act in the same way. For some constructions of wet meters it would be best to lead a discharge gas pipe from top of this tank, and waste the contents of gas, when a fresh supply of benzine is received. Another method is to attach the faucet to the top of the tank, or barrel, and connect the water pipe to the bottom, thus putting the contents of the barrel under the pressure of the water service, and preventing any influx of air, and precluding the existence of any vapor above the oil or benzine. And this arrangement can be modified by a separate vessel of water, in place of the water service of the city or town. For general convenience of application, and especially upon a large scale, where several barrels are to be stored, the gas connection is the most available, and the adoption of this method of preventing accident by manufactories and shops would be a real protection for property and life.

The storing of benzine under an *atmosphere* of gas, is open to an objection arising from the absorption of a small quantity of gas by the benzine itself. The only real trouble which will follow, will be the emission, for a short time, of a gaseous odor when the benzine is used; so far as the gas itself is concerned, it will be much improved in its illuminating powers by the absorption of a small proportion of vapor of benzine. B.

Franklin Institute.

Hall of the Institute, March 15, 1876.

The stated meeting was called to order at 8 o'clock, P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 165 members and 28 visitors.

The minutes of the last stated meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting the following donations were made to the library

Catalogue of U. S. Coast Survey Charts. Washington, 1875.

Report of the Superintendent of the U. S. Coast Survey, showing the progress of the survey during the year 1854. Washington, 1855 ; and during the year 1872. Washington, 1875.

On the Use of the Zenith Telescope for observations of time, by J. E. Hilgard.

On the Reclamation of Tide Lands, and its relation to navigation, by Henry Mitchell.

Treatise on the Plane Table and its use in Topographical Surveying.

Memoranda relating to the field work of the secondary triangulation, prepared by R. D. Cutts, assistant.

On the Air contained in Sea Water, by Oscar J. Jacobson.

Appendices Nos. 9 and 13 of Coast Survey Report for 1867.

Appendices Nos. 19 and 21 of Coast Survey Report for 1870.

Appendices Nos. 8, 16 and 17 of Coast Survey Report for 1871.

Appendices Nos. 12 and 14 of Coast Survey Report for 1873.

Report on Mt. St. Elias by W.H. Dull, acting assistant, U. S. C. S.

Discussion of Tides in New York Harbor, by Wm. Ferrel. From J. E. Hilgard, assistant in charge of office U. S. Coast Survey, Washington, D. C.

One year's subscription to War Dept. Weather Map, issued daily from Washington, with a file for the same. From L. T. Young, Philadelphia.

Bulletins 5 and 6 of the U. S. Geological and Geographical Survey of the Territories. Sec. Ser., Washington, January 8th, and February 6th, 1876.

Bulletins 1 and 2 of the U. S. National Museum. No 1, Check List of North American Batrachia and Reptila, by E. D. Cope.

No. 2, Contributions to the Natural History of Kerguelen Island, by J. H. Kidder, M.D. Washington, D. C., 1875. From the Dept. of Interior.

Report of the Meteorological Reporter to the Government of Bengal. Meteorological abstracts for the years 1867–'74. Calcutta.

Administration Report of the Meteorological Reporter to the Government of Bengal, for the years 1870–1875.

Report of the Midnapore and Burdwan Cyclone of the 15th and 16th of October, 1874, by W. G. Wilson, M. A. Calcutta, 1875. From Henry F. Blanford. Calcutta.

Specifications and Drawings of U. S. Patents for August, 1875. From the Commissioner.

Astronomical and Meteorological Observations made during the year 1873, at the U. S. Naval Observatory. Rear Admiral B. F. Sands, U. S. N. Supt. Washington, 1875. From the Supt.

Pennsylvania Archives Sec. Ser. Published under direction of M. S. Quay, Secretary of the Commonwealth. Vol. 3. Harrisburg, 1875. From the Secretary.

Constitution and By-Laws of the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, with the Act of Incorporation. Philadelphia, 1844.

Official Catalogue of the New York Exhibition of the Industry of all Nations. Revised edition, 1853.

Transactions of the Geological Society of Pennsylvania, August, 1834. Vol. 1, Part 1.

An Essay on Chemical Analysis, chiefly translated from the fourth volume of the last edition of the Traité de Chimie Elementaire of L. J. Thenard by J. G. Children. London, 1819. From Geo. W. Hall.

Twenty-fourth Annual Report of the Board of Water Commissioners to the Common Council of the City of Detroit, together with the Reports of the Officers of the Board for the year 1875. Detroit, 1876.

Die Congerien und Paludimenschichten slavoniens und deren faunen. Ein beitrag zur descendenz-theorie von Dr. M. Neumayr und C. M. Paul, 1875.

Das Gebirge und Hallstatt, eine geologisch-Palaontologische studie aus dem Alpen von Edmund Mojsisovics v. Mojswar, 1875. From the K. K. Geologishen Reichsanstalt. Wien Oestereich.

Transactions of the Royal Irish Academy. Vol. 24, Parts 9, 16 and 17. Vol. 25, Parts 1–20, inclusive. From the Academy. Dublin.

Aeneidea, or critical, exegetical and aesthetical remarks on the Aeneis, by James Henry. Vol. 1. Ireland, 1873. From the author.

Experiments with the alleged new force, by Geo. M. Beard, A.M., M.D. New York, 1876. From the author.

Memoire sur les occulations d'etoiles par les planets par J. A. Normand. Paris, 1876. From the author.

Eighth Annual Report of the Pennsylvania Society for the Prevention of Cruelty to Animals. Philadelphia, 1876. From the Society.

A paper by Mr. Jno. E. Wooten, of Reading, Pa., on "A combination of apparatus by which ordinary anthracite coal waste from the dust banks at the mines is successfully burned in stationary and locomotive boiler," was read by Dr. C. M. Cresson.

Some discussion followed, which was participated in by Drs. Koenig and Cresson, and Mr. Orr.

The Secretary presented his report, embracing L. T. Pyott's Hoisting Machine; D. M. Pfautz's Flying Draw Bridge; Walter Hart's Adjustable and Removable Flag and Banner Bracket; an impact Brick Machine, the invention of McLean & Bennor; a rapid and economical method of engraving, invented by M. Joyce, Washington, D. C.

Also an illustrated description of the subterranean wall being constructed for the preservation of the Falls of St. Anthony, Minn., with a letter from Maj. F. U. Farquhar, U. S. A., giving the progress of the work to February 21st, last.

Mr. Gray, who had been invited to exhibit and explain his system of Electro-Harmonic Telegraphy, was then introduced, and gave a large number of experiments illustrating the working of his system.

At the request of Mr. Robert Briggs, his description of Prof. Crook's Radiometer was postponed on account of the lateness of the hour.

A letter from Mr. B. H. Moore was read, acknowledging the receipt of the resolution passed at the last meeting in relation to his resignation as Vice-President, tendered at the last meeting, and repeating his request that it may be accepted, giving as reasons his impaired health and great press of private business.

On motion, the resignation of Mr. B. H. Moore as Vice-President was accepted.

On motion, the election of a Vice-President to fill the vacancy caused by the resignation of Mr. Moore, was postponed to the next monthly meeting.

The following gentlemen were placed in nomination for Vice-President: Mr. H. G. Morris and Dr. C. M. Cresson.

On motion, the nominations were kept open until the next meeting.

At the suggestion of Mr. Coleman Sellers, who was unable to be present at this meeting, the Secretary offered the following resolution, which was unanimously adopted.

Resolved, That the Secretary of the Franklin Institute be directed to invite the American Railway Master Mechanics to the Institute during their session in May, and that the Hall of the Institute be placed at their disposal for their meetings, if it can be arranged so as not to interfere with any of the uses or engagements of the Institute.

On motion, the meeting then adjourned.

J. B. KNIGHT, *Secretary*.

Preservation of the Falls of St. Anthony.—At the last meeting of the Institute the secretary gave an illustrated description of the work being executed by the U. S. Government, for the preservation of the Falls of St. Anthony, and read the following from Major F. U. Farquhar, under date of Feb. 21st, 1876,in relation to the progress of the work.

"Since the writing of my report for 1875, we have finished that part of the work under the east branch of the river, except the filling up of the passages, these being now about half filled.

"Under the main river the excavations and dyke have been carried to a distance of 1100 feet from the shaft, on Hennipin Island, or to within 200 feet of the end of the work in that direction.

"Just at the angle where the wall turns to go across the river, we encountered a stream of water, which brought into the excavation and passages a quantity of sand so great as take nearly three weeks to remove it. Except this, we have had no great drawback.

"The work being underground, we work during the winter, day and night, and but for a lack of funds, the dyke would have been finished by April 1st."

The St. Gothard Tunnel.—The St. Gothard Railway Company have just published their monthly statement of the progress of the works of the St. Gothard Tunnel during the month of December. The position of these works at the 31st of December, 1875, was as follows:—Total length driven, 5409 80 meters; length remaining to be driven, 9510 20 meters; total length of tunnel, 14,920 meters. The

following statement shows the monthly progress made during December, and the position of the different kinds of work at the end of 1875:

Description of works.	North side. Goeschenen. Length driven at 30th Nov.	Length driven in December.	Total length at 31st December.	South side. Airolo. Length driven at 30th Nov.	Length driven in December.	Total length at 31st December.	Total length at 31st December.
Leading heading...........	2771·5	39·3	2810·8	2509·0	90·0	2599·0	5409·80
Enlargement of roof......... ...	1372·8	188·0	1480 8	1074·0	78·0	1152·0	2632·80
Following tunnel or cuvette	1315·1	63·8	1378·9	790·0	51·0	841·0	2219·90
Enlargement of " " ...	603·6	90·2	693·8	479 0	51·0	530·0	1223·80
Completed tunnel.................	88·0	.	88·0	145 0	—	145·0	233·80
Masonry, arch.....................	692·0	40·8	732·8	825 36	4·64	830·0	1562·80
" east side wall.........	400·0	69 0	469·0	101·9	—	101·9	570·90
" west " "	414·5	44·5	459·0	690·6	39·1	730·0	1189·00
" invert.........	—	—	—	—	—	—	—
Diameter..........................	—	—	—	126·0	—	126·0	126·00

The Theory of the Height of Chimneys.—It will be noticed that the paper on "Steam Boilers and Chimneys," which appears upon other pages of this JOURNAL, passes over the steps of computation of the effect of temperature of the column of heated air on the draft—only giving the results. It is intended to recur to this subject again, at an early day, possibly in the May number ensuing, and then to exhibit more fully the anomaly of a maximum of induced velocity, at the temperature of 623·4° Fahr., and at the same time to *consider* the effect of the extra height of the column of heated air above the chimney, and endeavor to bring *it* into correspondence with the actual height of the chimney itself. The method of overlooking all specific resistances, and accepting a performance of a standard chimney as a basis, adopted in the article is, it is thought, new; and the results, as exhibited in the final table of the paper, are possibly less open to criticism than some which have been published. But the writer has frequently found, at the base of a chimney, an indication of water column, incompatible, in its great value, with the theoretical draft at *supposed* or *supposable* temperatures; and after the paper in question had gone to press, he was led to think that the effect of the ultra column of heated air in the atmosphere, would account for the discrepancy apparent in these cases; and also for the great efficiency of short chimneys at high temperature; as, for instance, those of marine boilers.

Railway Improvement and Extension in Great Britain. The half year ending December 31st, 1875, was marked by the unprecedented large return of traffic on the railways, exhibiting the flourishing condition of the business of the nation during the time; and the conclusion of the usual half yearly meetings of the companies permits the *Builder*, of March 18th, to publish a general statement at some length, which gives amongst other particulars the proposed expenditures of the leading companies for the current half year on new work. The total stated for eight companies is over twenty-two millions of dollars in currency, (at present rates), as the *authorized* current expenditures for improvements and extensions for the six months ending June 30, 1876.

Absorption of Hydrogen by Iron.—From the *Engineer*, Jan. 28th, 1876.—The well known French chemist, M. Gailletet, has continued his researches into the absorption of hydrogen by iron, with some interesting results. It appears that when an iron plate is attacked by sulphuric acid being poured over it, a portion of the hydrogen produced is absorbed by the metal, and the pressure of the gas which is accumulated between two iron plates, welded together, is sufficient to counterbalance a column of mercury 13¾in. high. This singular property of hydrogen, which has also been confirmed, lately, by the investigations of M. Sevox, is regarded by the latter as a most interesting discovery, and he attributes to the presence of carbonic oxide or hydrogenized gas, the brittleness which some classes of iron manifest when an attempt is made to draw them into wire, a fact well known to workers in this metal. It is also found that, when decomposing, by the galvanic battery, a solution of chlorate of iron to which sal-ammoniac has been added, metallic iron may be collected at the south pole in a form of a brillant wart, brittle and often hard enough to scratch glass. This iron after being washed, evolves, either under water or another liquid, numerous bubbles of gas, which is pure hydrogen. When freely exposed to the air, galvanic iron loses only a portion of its hydrogen; under water, especially water heated to 140 or 150 deg., the hydrogen is given off with violence. As to the quantity of hydrogen iron thus treated can take up, it seems that, for one volume of iron, the amount is two hundred volumes of gas; in weight. thirteen parts of iron absorb one part of gas. When a lighted match is applied to this iron, saturated with hydrogen, the gas burns like alcohol

Breakage of Submarine Telegraph Cables.—Sir William Thomson and Mr. F. J. Bramwell, to whom was intrusted the examination of the broken ends and the recovered section of the recent fractures of the direct United States Co.'s cable, have made their report.

There were two fractures, one on Sept. 27th, 1875, in 70 fathoms, and the other on Dec. 10th, 1875, in 120 fathoms.

They found the ends of the wire, of which the cable is composed, tapered down, as is always the case in good ductile metal. There was no evidence of decay or of an imperfect condition of the cable, nor of the cable chafing against the rock or crushing; and they can come to no conclusion but that the fracture occurred in a perfect cable, though thoroughly sound metal, and that they were due to that metal having been torn asunder, under violent tensile strain.

They further say, in regard to the first fracture, that this violent strain must have been caused by an implement, such as the arm of a grapnel or the fluke of an anchor, which, after coming in contact with the cable, was run along, driving the serving into the hemp, until there was formed a thick mass around the cable for a length of 13 inches. This mass finally stopped the progress of the implement, as is shown by its marks on the serving, and the breaking strain then commenced.

About 12 knots of the cable were recovered, and this was subjected to examination and test, and was found to be in excellent condition and free from fault. It was also submitted to test of breaking strain, and its power to resist tensile strain was placed at 7 tons.

This report offers no satisfactory explanation of how such a strain came to be applied, but concludes that it could not have been accidentally produced by fishing vessels in pursuit of their ordinary calling.

The steamer Faraday has also succeeded in picking up the fractured ends of the New Hampshire-Torbay cable, broken on Jan. 23d, 1876, at a depth of nearly 100 fathoms, and the representatives of the company state that the fracture presents the strongest evidence of having been produced by cutting with an axe or hatchet, after having been raised by an anchor; but whether this was done from malice, or in self-defense by a vessel under stress of weather, remains to be proven. In any view of the subject, there seems to be a necessity of some international law regulating the actions and responsibility of vessels in such cases, and to settle the question of jurisdiction in matters relating to submarine cables. K.

Civil and Mechanical Engineering.

GRAPHICAL AND ANALYTICAL DETERMINATION OF STRAINS IN A ROOF TRUSS

By A. Jay DuBois, C. E., Ph. D., Prof. Civil and Mechanical Engineering, Lehigh University, Bethlehem, Pa.

The present article is written in compliance with a request made to the author, to present in as popular a manner as possible the different methods of finding the strains in the various pieces of a roof truss of frequent occurrence in practice. The example here worked out accompanied the above request, and although perhaps not exactly calculated to show to the best advantage the peculiar merits of a graphical solution, will, we trust, be sufficient to enable the reader unacquainted with the method, to extend it to other and more irregular forms of trusses.

We shall first find the strains in the various pieces of the frame, due to dead load, by diagram; then indicate the methods of calculation, thus checking the results of diagram; and finally find the strains due to *wind force*, for which roof trusses are too rarely investigated, and for the determination of which the graphic method is peculiarly suited.

I. Outer Forces.—The truss proposed for solution is represented in Fig. 1. The span is 50 ft.; height of truss 12·5 ft.; diagonal bracing as shown in the Fig.; bottom tie horizontal without camber. The skeleton of the truss, drawn carefully to scale according to the given dimensions, we call the *frame diagram*. We have given it in Fig. 1, to a scale of 12 ft. to an inch for convenience of publication merely. In the actual determination of the strains which we shall give, it was drawn to a scale of 5 ft. to an inch. Now the *frame* diagram being thus carefully drawn to a suitable scale (in general the larger the better), we have first to determine the *outer forces* which

act upon the truss. In the example proposed each truss similar to Fig. 1, supported 5 ft. in length of roofing, and the total weight of this section of 5 ft., including slate, truss, roofing, etc., was 15 lbs. per sq. ft. Snow was taken at 5 lbs. per sq. ft. We have then for the length of each rafter, $\sqrt{25^2+12{\cdot}5^2}=\sqrt{625+156{\cdot}25}=\sqrt{781{\cdot}25}$ $=27{\cdot}95$ ft. or 28 ft. The total area of roof, therefore, for each section of 5 ft. will be $28\times5\times2=280$ sq. ft. At 15 lbs per sq. ft. this will give 4200 lbs. For snow, we have in addition $280\times5=1400$. Hence, total maximum load including snow, is $4200+1400=5600$ lbs. Now this load we may consider as divided into a series of loads at each apex; *omitting the two ends*, at which strictly we have 400 lbs. apiece. The strain in the rafter is in reality cumulative, increasing towards the ends. By the above method we find this maximum strain at the end correctly, and then consider the cross-section uniform to next apex, thus getting somewhat more than the area necessary. At each of the seven apices, then, omitting the ends, we have a vertical weight of 800 lbs., as represented in Fig. 1 by the vertical arrows. At the ends we have a vertical upward reaction of half the total weight, or 2800 lbs. Thus all the *outer forces* which act upon the truss are known, and it remains to find the strains caused by these forces in the various pieces. This we shall do in two ways—1st, by diagram; 2d, by calculation.

I. GRAPHIC SOLUTION.

II. NOTATION.—Let us first explain the notation which we have adopted for Fig. 1. Let all the space above the truss be denoted by the letter A, and all below it by the letter B, and then number the spaces within the truss by 1, 2, 3, 4, 5, 6, etc. Then the four pieces composing the rafter are A 1, A 2, A 4 and A 6; the three divisions of the tie are B 1, B 3, B 5, while the braces are 1 2, 2 3, 3 4, 4 5, 5 6, and 6 6′, respectively; corresponding spaces in the right half being denoted by primes. The great convenience of this system of notation will soon appear. [For the above elegant system of notation we are indebted to *R. H. Bow's* "*Economics of Construction*," where the reader will find the following method of graphic solution very clearly set forth, and illustrated by numerous examples.] The preceding system of notation being understood, we can now proceed to the principles of which we shall make use, in the solution of the problem before us.

III. General Principles.—The principles of which we make use in this and all similar problems, are very simple and familiar to all. They are indeed among the most elementary in mechanics. The problem proposed is essentially a *statical* problem. That is the end to be obtained is rest or *equilibrium.* Thus at each apex, as we have seen, we have an outer force acting. The tendency of this force is, of course, to cause motion of the material point upon which it acts. But the force at each apex causes strains in the pieces which meet at that apex, and these strains must be so great and must act in such direction, that they exactly oppose and neutralize the action of the outer force. That is, *at each apex the strains in all the pieces which meet at that apex, are in equilibrium with the outer force which acts upon that apex.*

Now the principles of which we make use, and which here directly apply, are as follows:

1st. *If any number of forces, all in the same plane, are in equilibrium, the polygon formed by drawing lines parallel to the directions of these forces, and equal by scale to their intensities, must close.*

It will be seen at once, that, according to this principle, if we have only three forces acting upon a point and holding that point in equilibrium, and if *one* of these forces is known; then, if we draw a line parallel to the known force, and make it equal by scale to the known intensity of that force, the other two forces can be easily and directly determined *to the same scale*, by lines respectively parallel, which are prolonged till they intersect and thus close the polygon, which in this case is a triangle. Generally, no matter how many forces act upon the point in question, if they are in equilibrium, and if we know all but two of them, we have only to lay off to scale the known forces in the proper directions, and then "close" the polygon thus commenced by lines parallel to the known directions of the two unknown forces. We thus find to scale the intensities of these forces necessary and sufficient for equilibrium. If more than two forces are unknown, the problem is in general indeterminate.

Corresponding to this method of diagram, we have a method of *calculation*, which consists simply in solving trigonometrically the triangles and polygons thus obtained.

2d. *If any number of forces acting upon a point are in equilibrium, and if we take any point in the common plane of the forces as a centre of moments, then the tendency to rotation about this point is*

zero, or the sum of the moments of all the forces tending to cause rotation in one direction is exactly equal and opposite to that tending to cause rotation in the opposite direction.

The principle is self evident if there is to be equilibrium or no motion, and upon it we may base a perfectly general method both of diagram and calculation. It will thus be seen, that by these two principles we have *four* different and distinct methods of solution; two by diagram and two by calculation. The first method of diagram which we shall here make use of, is known very generally as *Prof. Clerk Maxwell's* method, the corresponding method of calculation may be called the method by "composition and resolution of forces."

The second principle gives rise to a method of calculation which is simple, easily acquired and applied, and perfectly general, provided all the *outer forces* are known. This method we may call the *method of moments* or "Ritter's method." Prof. August Ritter in his work entitled *Dach und Brüchen Constructionen*, has shown so exhaustively the generality of the method, and applied it in such detail to so many forms of construction, that although the principle is itself as "old as the hills" it well deserves to be thus known by his name.

Now, corresponding to this general method of moments, we have a *method of diagram* equally general, which lies properly at the basis of the new science of "Graphical Statics," and which, for similar reasons, we may call "*Culmann's method*"—in compliment to the man who, more than any other, has done most for its perfection and elucidation. This second method of diagram we shall not touch upon here, but refer the reader for an exposition of *all* these methods, together with their dependent principles, illustrated by numerous examples, to the author's work upon the "*Elements of Graphical Statics*," etc.; John Wiley & Son. We shall, however, in what follows, make use of the first method of diagram above, as also of its correlative method of calculation, and shall also notice briefly the method of calculation by moments, which rests upon the second principle above enunciated. Although we shall here illustrate these principles by a single concrete example, the reader will, we trust, find no difficulty in applying them to *any* example which can occur in practice. Even in bridges, if he will thus find the strains in every piece due to each *separate* apex load considered by itself, and then form a table showing the strains thus found for each load, he can easily and unerringly pick out the maximum strain which, under any possible combination of

loads, can occur in any given piece. [For an exposition of this method, see also the work of the author above cited.] Thus for every framed structure, of whatever kind, we have a simple and general method, and the real solution of the problem in any case is in reality confined to finding the *outer forces* which act upon the structure. These in roof trusses, simple bridge girders, etc., are easily found. The weights are always known, the reactions at the ends easily found by the "law of the lever." For continuous girders or girders continuous over more than two supports, for braced arches, etc., these outer forces, more especially the "reactions," are not so easily found. Once known, the solution is easy. The whole problem of solution of framed structures is thus reduced to finding the *outer forces*. In all ordinary engineering structures these are easily found, and hence, no difficulty is experienced. For those structures of less frequent occurrence, already noticed, the determination of the outer forces for *each separate apex load considered by itself*, is by no means so difficult as has generally been supposed. This, as we have seen, is, however, all that we need; and for such methods of determination, we refer again to the above work of the author.

IV. APPLICATION OF THE ABOVE GENERAL PRINCIPLES.—Let us now proceed to apply the general principles of Art. III, to the case in hand. We take up, therefore,

1st. *Maxwell's Method of Diagram.*—In Fig. 1, we have acting at the toe of the rafter, an upward reaction of 2800 lbs. This upward reaction causes strains in the pieces A 1 and B 1 (see Art. II for notation). According to our first principle then (Art. III), the strains in A 1 and B 1 must, with the reaction of 2800 lbs., form a system in equilibrium; and hence, the polygon formed by parallel lines must *close*. This polygon we call the *strain polygon*. Thus in Fig. 2, we lay off the distance A B, equal to 2800 lbs., by scale. In the figure we have taken 3200 lbs. to an inch. In the actual example we took 800 lbs. per inch, but have reduced the original diagram, for convenience of size. A B, then, is by scale 2800 lbs. We draw, then, A 1 in Fig. 2 parallel to A 1 in Fig. 1, and B 1 parallel to B 1, and produce these lines to intersection 1. The polygon is then closed, and A 1 and B 1 measured off to scale, will give at once the strains in the corresponding pieces.

We have now to call attention to a *very* important point. We have thus far the intensity of the strains in A 1 and B 1, but have yet to

find whether these strains are compressive or tensile. For this we have the following rule:

Follow round the strain polygon, in the direction of the known forces. We thus obtain certain directions for the unknown forces. Refer these directions to the apex at which the forces considered are supposed to act; a direction away from this apex is tension—towards, compression.

Thus, in the above case, we *know* that A B acts up. We follow round then, with this to guide us, from B to A; and then continuing round from A to 1, and 1 to B again. Now, looking back to the frame, we find A 1 acting towards the foot of rafter, which is the apex now considered, therefore compression; while 1 B acts away, therefore tension. The amount of compression or tension is indicated by the length to scale of the corresponding lines.

Now, having found A 1 a certain number of pounds compression, as shown in Fig. 2, we can find 1 2 and A 2; because at the apex, where these forces meet, we know two forces acting there, viz.: A 1 already found, and A A = 800 pounds given, and there are only two others unknown, viz.: 1 2 and A 2. A 1 and A A are shown in Fig. 2, already drawn to scale. A 2 and 1 2 closing the polygon commenced by these two forces, give at once to the same scale the strains in the corresponding pieces. Again as to the *quality* of the strains, observe that A A the weight, acts *down*. We pass round then, with this to help us, from A to 2 and 2 to 1, and so around. Then referring to the apex *at which all these forces act*, we have A 2 towards, therefore compression, and 1 2 ditto, and if we should still go round, A 1 also towards the new apex, or compression, as before found, thus checking our previous result.

Now we can pass to the first apex on the lower tie, because we know already B 1 and 1 2, and have only to find two unknown strains, 2 3 and B 3. We draw then in Fig. 2, 2 3 to intersection with B 1. We have then B 1, 1 2, 2 3 and B 3, closing the polygon. B 1 has already been found to be tension. With reference to the apex we are *now* considering, therefore, it acts *away;* we follow round then from B to 1, then 1 to 2, and then 2 to 3 and 3 to B again, and thus find bý reference to the frame, 1 2 compression as already found, 2 3 tension, and 3 B tension. Now knowing A 2, 2 3, and the weight 800 pounds = A A, we can find A 4 and 3 4 as before, both compression. So we pass through the frame. Next time with B 3 and 3 4 known, we

find 4 5 and B 5; then with A 4, 4 5 and the weight A A all known, find A 5 and 5 6. Now knowing A 6 and the weight A A = 800 pounds at summit, we find A 6′ and 6 6′, the one compression, the other tension. Observe that as we proceed, now finding the strains in the right hand half of the truss, we *check* each time our previous results. The diagram thus checks its own accuracy. The points 6 and 6′, 4 and 4′, 2 and 2′, are vertically over each other. If at any point we have committed an error, we can thus detect and remedy it. Observe, also, that while all the seven weights A A = 800 pounds, act downwards, the two reactions A B and B A act upwards, and just come back to the point of beginning, thus closing the "polygon," which in this case is a straight line, in accordance with our first principle, Art. III. In the case of wind force, or inclined reactions, this polygon is a true polygon instead of a straight line, as we shall see hereafter. This polygon we call the *force polygon*. We have thus the *frame diagram*, the *strain diagram*, and the *force polygon*. In every case, since the reactions are called forth by the outer forces, this latter must close. Unless it does close, we have not found the outer forces correctly, and cannot proceed to form the strain diagram. The strain diagram being completed as above, and checking its own accuracy, we can scale off with the dividers the strains in every piece. Representing compression by + and tension by — we thus find, for the lower flanges: B 1 = — 5624, B 3 = — 4832, B 5 = — 4024; for the upper flanges: A 1 = + 6280, A 2 = + 5816, A 4 = + 4712, A 6 = + 3584, and for the diagonals: 1 2 = + 720, 2 3 = — 720, 3 4 = + 1048, 4 5 = — 928, 5 6 = + 1472, 6 6′ = — 2410. As the liability to error of the author working rapidly does not exceed $\frac{3}{100}$ths of an inch, these strains may be depended upon within 2 4 or 2 5 pounds. In the Fig. 2, compression is represented by heavy lines. The checking of both halves of Fig. 2 gives us assurance of the correctness of our results.

2d. Corresponding Method of Calculation.—We can still check our results by calculation. We have only to solve trigonometrically the triangles of Fig. 2. This from the known weights, reactions and proportions of the frame, we can easily do. The *quality* of the strains, whether tension or compression, is easily determined as before. Thus, Fig. 2 comprises a set of *rules*, by which we may calculate the strains directly, without tedious and elaborate reasoning as to the way in which strains are "resolved," etc.

For instance, from Fig. 2, we see at once that A B $\times$ sec B A 1 = strain in A 1, and A B $\times$ tan B A 1 = strain in B 1. Now sec. B A 1 $= \frac{27 \cdot 95}{12 \cdot 5}$ and A B = 2800, therefore str. in A 1 $= 2800 \times \frac{27 \cdot 95}{12 \cdot 5}$ = 6260, against 6280 as found by diagram. Again, tan B A 1 = $\frac{25}{12.5} = 2$, hence strain in B 1 = 2800 $\times$ 2 = 5600 lbs., against 5624 as found by diagram. Again, directly from Fig. 2, we have, strain in 12 = (A A $\times$ cos A 1 B) $\times$ sec. of the angle which 1 2 makes with the perpendicular to A 1. For the secant of this angle we easily find 1·008. Now, A A = 800 and cos A 1 B = $\frac{25}{27 \cdot 95}$ hence strain in 1 2 $= \left(\frac{25}{27 \cdot 95} \times 800\right) 1 \cdot 008 = 721$ lbs., against 720 found by diagram.

Again from the Fig. A 1 — A A sin A 1 B — [A A cos A 1 B $\times$ tan of angle of 1 2 with perp. to A 1] = A 2. But A 1 we have already found 6260, A A = 800, sin A 1 B $= \frac{12 \cdot 5}{27 \cdot 95}$ cos A 1 B = $\frac{25}{27 \cdot 95}$ and for the tan. above, 0·126, hence A 2 = 6260 — 357·8 — 90·1 = 5812 lbs., against 5816 as found by diagram. So we can go through the whole system of triangulation shown in Fig. 2 and check our results. It is advisable to use logarithms, instead of natural sines, etc., as above.

The above methods are of course perfectly general and apply to *any* form of roof truss. In the case, however, of a curved roof truss, the method of diagram is always equally simple and ready of application, while the corresponding method of calculation is often tedious and involves much intricate trigonometrical computation. In fact, just here is the great advantage of the graphic method, that while perfectly general, it is unaffected by the irregularity of the frame. One case is no more difficult than another.

3*d. Method of Calculation by Moments.*—We have still to consider the method of calculation based upon our 2d principle, Art. III. Eor the method of diagram corresponding to it, we must refer to our work upon "*Graphical Statics*," already quoted, as its development would far exceed the limits of the present article. We may only remark here that upon it has been founded an entire system of statics, not less elegant and far more general than the above method of dia-

gram. Thus it will be observed that the method of diagram already noticed, applies only to *framed* structures or structures in which the strains must follow certain *definite directions;* the latter method, on the contrary, applies as well to solid structures also. For the application of the first method all the outer forces must first be known; by the second, these forces may themselves be found. Though some few of the principles of this method have long been known and applied, notably by *Mery* (*Ann. d. ponts et chauss.*, 1840, *sem.* 1 *p.* 50) to the stone arch, yet its thorough development and the deduction of a regular system applicable to all statical problems, of which the arch is but one of many diverse problems, is due entirely to *Culmann*, ("*Die Graphische Statik*," 1866), and by his name it may well be called. The corresponding method of *calculation* owes, as already stated, much of its development to *Ritter*,* and to that we shall now proceed.

Thus, according to our 2d principle, Art. III, if we suppose a section made entirely through the truss, cutting all the pieces which it meets, then for equilibrium the algebraic sum of the moments of the strains in these pieces with reference to any point, must be balanced by the algebraic sum of the moments of all the outer forces acting upon the section of the truss right or left of the points of division, with reference to this same point. Now we know all the outer forces. Since our centre of moments may be *anywhere* in the plane, we have only to assume it *at the common point of intersection of all the cut pieces except one.* The moments of the strains in these pieces will then be zero, and we have only the moment of one unknown strain balanced by known moments. If now we know the lever arm of this unknown strain, it is itself easily found. Thus suppose in Fig. 1, we were to take a section cutting the pieces A 2, 2 3 and B 3. If we take the centre of moments at the common intersection of 2 3 and B 3, the moments of the strains in these pieces with reference to this point will be zero. Considering then the left hand section, we have the moment of the reaction acting up and causing, therefore, compression in A 2, *minus* the moment of the first apex weight, balanced by the moment of the strain in A 2. The lever arm for A 2 we easily find to be 3·72 ft. Hence strain in A 2 $\times$ 3·72 $=$ 2800 $\times$ 8·333 $-$ 800 $\times$ 2·08 $=$

* In the author's work upon Graphical Statics the method is further applied to the continuous girder, draw-span, braced iron and stone arch, etc., and shown to be of universal application.

21669·333 hence strain in A 2 $= \frac{21669 \cdot 333}{3 \cdot 72} = + 5855$, against 5816 as found by diagram.

Again suppose A 1 cut, we have the same lever arm as before, *i. e.* 3·72, but no apex weight left of the section, hence simply A 1 $\times$ 3·72 $= 2800 \times 8 \cdot 33$ or A 1 $= \frac{23333 \cdot 333}{3 \cdot 72} = 6272$ against 6280 as found by diagram.

Again, cutting B 1 and taking the point of moments at intersection of 1 2 and A 1, we have B 1 $\times 3 \cdot 12 = - 2800 \times 6 \cdot 25$, or B 1 $=$ $\frac{17500}{3 \cdot 12} = - 5607$, against 5624 as found by diagram.

So we proceed, cutting each flange and taking the apex opposite to that flange as a point of moments, and taking the moments of all the forces left of the cut flange, with proper signs, and equating to the moment of the strain in the cut flange. The method for the diagonals is precisely similar. Here the intersection of the other pieces is at the end of the truss, which may then be taken as a common point of moments for all the diagonals. In any case, the main and only difficulty is the determination of the various lever arms; for a curved roof truss this involves much calculation. Such calculations, though sometimes long, are, however, always simple, and the lever arms may even be measured off to scale from the frame diagram with sufficient accuracy.

We have thus, as we see, two independent methods of calculation, and one (properly two) method of diagram, either of which are simple and perfectly general. Of the methods of calculation, the last is to be preferred as the simplest, and easiest of application. The method of diagram will, in most cases, be found preferable to all. Especially is this the case when we consider *wind force*, to the discussion of which we shall now proceed.

II. WIND FORCE.

V. It is of considerable importance to investigate the influence of a partial load, such as that caused by the wind blowing upon one side of the roof, and this, by the aid of our graphic method, we can easily do.

If P is the intensity of the wind pressure in pounds per square foot upon a surface perpendicular to its direction; *i*, the inclination

of any plane surface to this direction; P_n the normal pressure, P_h the horizontal component of this normal pressure, and P_v its vertical component; then we have

$$P_n = P \sin i^{\,1.84 \cos i - 1}.$$
$$P_h = P \sin i^{\,1.84 \cos i}.$$
$$P_v = P \cot i \sin i^{\,1.84 \cos i}.$$

(See "*Iron Bridges and Roofs*," Unwin, p. 120, also, "*Elements of Graphical Statics*," DuBois, Art. 11.) If the wind blows horizontally, and if $P = 40$ pounds, then

For $i = 20°$ we have $P_n = 18{\cdot}1$, $P_v = 17{\cdot}$, $P_h = 6{\cdot}2$.
For $i = 30°$ we have $P_n = 26.4$, $P_v = 22{\cdot}8$, $P_h = 13{\cdot}2$.

Now in the case under consideration, $i = 26° \; 34'$ nearly, therefore we have $P_n = \frac{18{\cdot}1 + 26{\cdot}4}{2} \times 6{\cdot}98 \times 5 = 800$ pounds nearly, or the normal pressure at each apex, for $P = 40$ pounds, is about the same as the load upon the roof itself. We have also,

$P_v = \frac{17 + 22{\cdot}8}{2} \times 5 \times 6{\cdot}98 = 700$ nearly, and $P_h = 514$ at each apex.

If now at each apex we have 700 pounds acting vertically downwards, if the wind blows on, say from the left, and if the left end is fixed, the right being placed upon rollers to allow expansion; then the reaction at the left is for the first apex load,

$R_1 \times 50 = 700 \times 43{\cdot}75 - 514 \times 3{\cdot}12$, or $R_1 = 580$.
For the second, $R_2 \times 50 = 700 \times 37{\cdot}5 - 514 \times 6{\cdot}24$, or $R_2 = 525$.
For the third, $R_3 \times 50 = 700 \times 31{\cdot}25 - 514 \times 9{\cdot}36$, or $R_3 = 437{\cdot}5$.
For the centre, $R_4 = \frac{350}{2} - \frac{257}{4}$ or $R_4 = 111$ pounds.

The entire reaction at the left end due to wind, therefore is,

$$R = 580 + 461 + 341 + 111 = 1493 \text{ pounds.}$$

We can now, therefore, form the force polygon of Fig. 3, by laying off in succession, to scale, the apex normal forces of 800 pounds each, viz.: A A, etc., equal to P_1, P_2, P_3, and the last, P_4, $= 400$ pounds. Then drawing the verticals A a and B b, making A a equal to 1493 pounds, and drawing the horizontal a B. The force polygon thus closes, as it should. We have at the left end the vertical reaction A a, and the horizontal force a B. These two forces are in equilibrium with the strains in A 1 and B 1, hence lines parallel to these pieces must close the polygon. Thus we obtain B 1 and A 1, Fig. 3. So we go through the frame, precisely as before, and then

scale off the strains. We thus find B 1 = — 4464 pounds, B 3 = — 3568 pounds, B 5 = — 2680 pounds, A 1 = + 3584, A 2 = + 3480, A 4 = + 2640, A 6 = + 1784, A 6′ = + 1980, also, B 1′ = — 3608, B 3′ = — 2584, B 5′ = — 2232, and A 1′ = + 1688, A 2′ = + 3472, A 4′ = + 2584. And for the diagonals 1 2 = + 800, 2 3 = — 800, 3 4 = + 1208, 4 5 = — 1016, 5 6 = + 1608, 6 6′ = — 1608, 5′ 6′ = + 320, 4′ 5′ = — 408, 3′ 4′ = + 480, 2′ 3′ = —952 1′ 2′ = + 800. We can now pick out the greatest of these strains for any piece, and taking it together with the strains already found for dead load, we have the maximum strain in every piece. It will be seen that the strains for wind are very considerable, and should by no means be disregarded. In fact in some roof trusses, the effect of the wind is to *reverse* the strains due to dead load in some of the pieces, which should, therefore, be counterbraced.

We may, if we wish, check the above results, by either of our two methods of calculation, but the operations will be found still more tedious, and in curved roof trusses, very complex and intricate. By the graphic method however, no difficulty is experienced.

VI. Economical Angle.—Let a be the angle between the rafter and tie. Then if u is the load per unit of horizontal length, we have for the compression at foot of the rafter, if s is the span,

$$\frac{us}{2} \sin a + \frac{us}{2} \cot a \cos a.$$

But the length of the rafter is $\frac{s}{2 \cos a}$, hence,

$$\frac{s}{2 \cos a}\left[\frac{us}{2} \sin a + \frac{us}{2} \cot a \cos a\right] = \frac{us^2}{4} (\tan a + \cot a),$$

represents the weight of the rafter. Differentiating and putting the first differential coefficient equal to zero, we have $\frac{1}{\cos^2 a} - \frac{1}{\sin^2 a} = 0$, or $\tan a = 1$, or $a = 45°$. Therefore, 45° is the most economical angle for a girder of this kind with straight bottom flange.

If the rafter is considered as a beam continuous over five supports, as strictly it should be, this result is somewhat altered, and we have $43\frac{1}{2}°$ as the angle of economy. In both cases the bracing is disregarded, as it is theoretically nearly constant. In reality, long compression members need extra material for stiffening, and hence our result is not strictly correct.

The above completes our discussion of the problem proposed. We trust that the attentive reader, interested in such questions, will be

Graphical and Analytical Determination of Strains in a Roof Truss,

By A. Jay DuBois, *Prof.*, *etc.*,

Lehigh University,

Bethlehem, Penna.

Fig. 1.

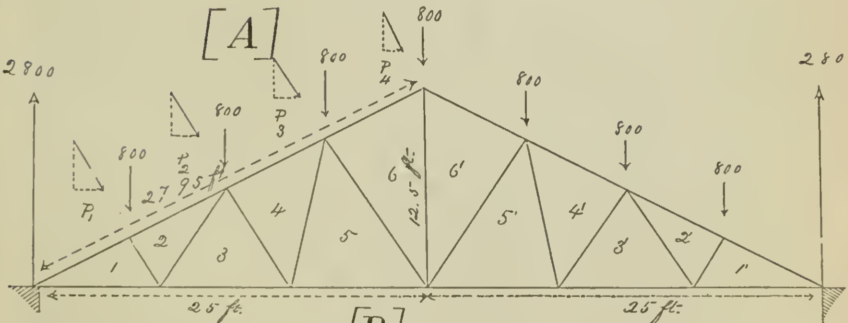


Fig. 3.

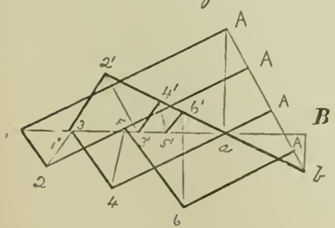
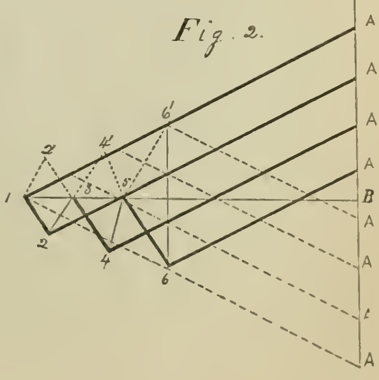


Fig. 2.



Scale of length, 12 ft. to an inch.
Scale of force, 3200 lbs. to an inch.

able to apply now the above principles for himself to any case that may arise. There are certainly several points of more or less importance which we have been unable to touch upon, but none which he will not, we think, be able to settle for himself. We have scarcely been able to more than hint at the graphical method based upon our second principle, Art. III, and yet it is upon this that the real method of graphical statics properly rests. Should the above serve to call attention to this branch of engineering science, which is at present attracting so much attention, our purpose will be abundantly accomplished.

The literature of the subject in English is already sufficiently extended. In the work of *R. H. Bow*, already quoted, a large number of diagrams for various forms of roof trusses will be found. Once familiar with the fundamental principle, the reader will find no difficulty in following through such examples at sight. In the *Engineering News* will be found a series of very excellent articles, by *Prof. Chas. E. Greene*, in which "Maxwell's Method," as applied to roof trusses, will be found very clearly and thoroughly elucidated. The same author has also in a work entitled "Graphical Method for the Analysis of Bridge Trusses," giving an original, and in many respects, very practical solution for continuous girders and draw spans. In German we have the works of Culmann, Bauschinger and Winkler. In French, of Levy. In the work of the author, entitled the "Elements of Graphical Statics," will be found a thorough presentation of *all* the various graphical methods, together with a complete list of the literature upon the subject, and applications to the continuous girder, draw span, braced arch, etc., illustrated by numerous practical examples.

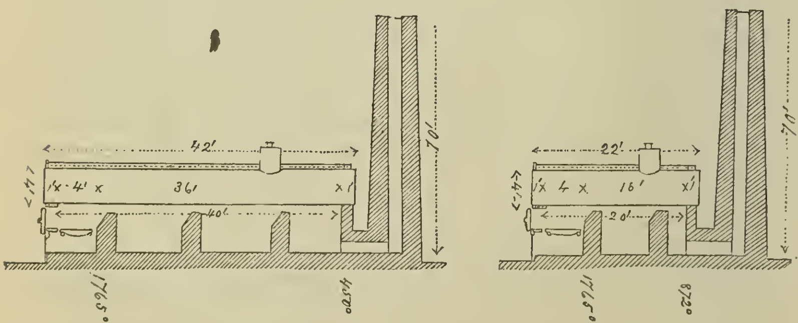
Technical Terms.—The *Camberwell and Peckham Times*, in reporting the proceedings of the "Camberwell Vestry," (Anglice local governing board for Camberwell and Peckham), represents the following colloquy to have taken place during a discussion of a proposal to plant certain roads in the parish with trees, viz: "Mr. Grummant estimated the expense of the trees as being about 100*l*. He said that every tree would require a cradle, and then the ground round about would have to be paved with half sovereigns," (laughter). The surveyor explained that the term "half sovereigns" meant small "pitchers." Mr. Weller, amidst much confusion, protested against the term "half sovereigns" being applied to the stones when there was a proper name (*i. e.*, small pitchers) that might be used. Mr. Wesson (chairman): "Sit down; you shall have the order."—The *Builder*, London, Feb'y 5th, 1876.

STEAM BOILERS AND CHIMNEYS.*

The Relations of Grate Surface to the Horse Power and Chimney Dimension of Stationary Steam Boilers.

By Robert Briggs, C.E.

Some years since a Committee of the Franklin Institute, in a preliminary report upon the horse power of steam boilers, attached the largest importance to the extent of grate and adequacy of the chimney and flues, to burn the fuel; with a minor estimation of the value or effect of heating surface, only insisting that such surface should, by right, be capable of producing a certain economy of evaporation. These propositions were obvious, at least to one of the members of the committee, and were generally conceded by the others; so that no demonstration was then thought necessary; but it appearing at this time that these opinions should be supported by data, the following examination of the subject is offered:



Let it be supposed that there are taken, for examples, two plain cylindrical boilers, the first 42 ft. × 4 ft. diameter, and the second 22 ft. × 4 ft. diameter; each of these boilers are to have 4 ft. × 4 ft.^{2} = 16 square feet of grate, and the settings are to be so made as to take off 1 ft. at each end, so that 40 ft. long of the first, and 20 ft. of the second, will be exposed as heating surface, either directly

*Journal Franklin Institute, new series, Vol. xcii, (July, 1871), page 91.

to the fire, or to the gases of combustion. Let it be further supposed that each of these boilers have chimneys 70 feet in height, and $1\frac{1}{3}$ feet of cross area, and that baffling bridge walls be suitably built to insure contact of gases, and that in every respect, except the heating surface, the boilers be placed upon equality of arrangement.

The longer of these two boilers will then be a fair specimen of a plain cylinder boiler, of approved proportions, in all regards (except possibly the chimney section, the size of which will be qualified hereafter). The ratio of heating surface to grate surface will thus be 15 or 16 to 1, which is that usually adopted for boilers of this kind; it can, therefore, be confidently assumed that the grate of this boiler will burn with ease, *by good firing*, 12 pounds of egg or steamboat anthracite coal, exclusive of any ashes or cinders, per square foot of grate per hour; and that the heat proceeding from the combustion, will be absorbed to the extent, that the gases of combustion will escape up the chimney at about 450° Fah., when steam of 60 lbs. pressure, or 305° Fah., is generated from the water in the boiler.

In estimating the effects of combustion under this boiler, the total heat from a pound of the fuel may be taken at 15,000 units, less 10 per cent. for imperfect combustion, or 13,500 units, and the proportion of 24 pounds of air to each pound of combustible, will be accepted; and it will then be seen, after making up the figures, that the gases of combustion at 450°, air being taken at 60°, will carry off 2300 units of heat, leaving 11,200 units as the available quantity imparted to the boiler; or the equivalent to 11·6 lbs. of water evaporated for each pound of coal burnt upon the grate, supposing that no heat is lost in heating up the setting, or given out (lost) from boiler or setting.

If now it be admitted that one-fourth of the heat proceeding from the fire, is given out in the fire place by immediate radiation and conduction, to the boiler over the fire, it will be found by calculation that the temperature of the twenty-four pounds of gases of combustion, when passing over the bridge wall of the furnace, will be 1765° Fah. This supposition of the giving out of one-fourth of the heat by radiation is probably very close upon the existing fact for *underfired boilers*, when the grate is far enough removed from the boiler for the proper ignition of the coal, and also of the evolved combustible gases between the surface of the coal and the boiler. For fire-box boilers, probably one-third the heat is dispersed in the fire box.

Taking, therefore, 1765° as the temperature of the gases passing the fire bridge, and 450° as the temperature of the gases escaping into the chimney, and 305° as the temperature of the boiler, it results that the loss, or giving out of heat at any intermediate points in the length of the boiler (36 feet), will be proportionate to the differences of temperature at those points, giving the temperature of the flames or gases as follows:

At the fire-bridge,	1765°,	20 ft. away,	711°,
2 ft. away,	1589°,	22 "	662°,
4 "	1425°,	24 "	619°,
6 "	1300°,	26 "	581°,
8 "	1179°,	28 "	548°,
10 "	1073°,	30 "	519°,
12 "	980°,	32 "	494°,
14 "	900°,	34 "	470°,
16 "	828°,	At the chimney,	450°.
18 "	766°,		

It now remains to be shown what will be the effect of removing one-half of the convective surface of the boiler, or in other words, what happens, if the same grate, setting, chimney, etc., and equal *care* in firing, is applied to a boiler; with 16 ft. length of shell, behind the bridge wall, in place of 36 ft.;—with a total length of exposed fire surface of 20 ft., in lieu of 40 ft. It is at once obvious that, without noticing any other effect of the change upon the process of operation, the escaping gases would enter the chimney at 828°, instead of 450°, causing a loss of 378° of heat at this point, which corresponds to the loss of 2255 units of heat above what before occurred, or about 20 per cent. of the total heat available for making steam from the fuel. But the effect of thus heating the chimney will be to increase the draft, and to accelerate the combustion; and as the loss here stated, will appertain to any increased quantity of coal which may be burned, as well as to the normal quantity assumed for the 40 ft. boiler; it will be requisite to demonstrate that 24 per cent. more coal will be induced to burn upon the grate by such increased draft, to provide the *same* quantity of heat to the water of the 20 ft. boiler, as was assumed for the 40 ft. boiler.

An examination into the conditions of the draft of chimneys shows some curious anomalies of figures. The source of power for the draft of a chimney is the difference of weight of the column of heated gases, as compared to that of the same column of atmospheric air,

(which is here assumed at the temperature of 60°). Between 450° and 900°, the velocity of efflux of gases of combustion, under the inducement of the pressure given by the difference of weight of the column, compared with that of air, is such that, in consequence of the increase of volumes at different heats, a very nearly constant *weight* of gases will be expelled for any given interval of time. The combustion of 12 lbs. of coal per hour, with a ratio of one-twelfth of a square foot of chimney to the square foot of grate, and with the supply of 24 lbs. of air to the lb. of coal, is equal to the passage of one pound of gases per second through a square foot of chimney. But a computation gives the time for the passage of one pound of gases, by the inducement of a 70 ft. high chimney:

At the temp. of	450°	500°	600°	700°	800°	900°.
Time in secs., dec.,	0·401	0·397	0·393	0·394	0·397	0·401.

This gives the effective force of the chimney for passage of gases, neglecting all frictions or sources of resistance, as a constant of $2\frac{1}{2}$ times what is needed, [height $4\frac{1}{4}$ times greater than requisite].

Although the chimney is the source of draft, and its proper dimensions for the passage of the gases an essential element in the calculation, the resistances to be taken into account are: first, that of the entrance of air through the grate and coal; next, that of the passage of gases over bridge walls, and around corners; and finally, that of the chimney flue. Of these three the resistance of air supply to the grate and through the coal is much the largest.

It has been shown that for the supposed chimney and rate of combustion, two-fifths of the effective power of the levity of the gases will have been absorbed in giving motion to the gases themselves; leaving three-fifths to overcome the other resistances. The rate of passage of the air through the grate, can also be estimated by the effect of the difference of the weight of columns, and the result proceeding therefrom, under differences of temperature, will be found quite different from that of the passage of the gases, as the density and volume of the air is constant, while the weight of the chimney columns vary. Upon the same grounds of combustion, chimney, etc., and with the assumption that the interstices of the coal are equivalent to the area of the chimney, (that is one-twelfth the area of the grate—a low estimate), the time of passage through the coal of the

24-25ths pounds of air, needed each second to burn the 1-25th pound of coal, is

For chimney temp. of	450°	500°	600°	700°	800°	900°.
Time in secs., decimals,	0·297	0·287	0·270	0·259	0·251	0·243.

This gives the effective force of the chimney, for the passage of air through the interstices of coal, when all frictions or sources of resistance are neglected, as a variable quantity, of from three to four times what is needed, [or an excess of height of this chimney of from 8 to 15 parts].

The proportions of chimney to grate, and combustion assumed, are those which have resulted from practice, *where the proper constant for resistance of passage of gases in the chimney or flues is not added.* If the cross area of the chimney is taken at 0·7 the area of the grate, divided by the square root of the height of the chimney, and a half square foot of area be added to equalize the frictions of the sides; an approximate rule for the least area desirable, will be obtained, for square or round chimneys, sufficiently accurate for practice. In treating of the capacity of such a chimney, for the flow of gases, or for inducing the entrance of air, the *constant* area should be neglected.

The rate of combustion, and the relations of temperature, all refer to the example here offered, and the excess of power of the chimney, both for passage of gases, and for entrance of air, is expended in the various resistances. It has been shown that at 450°, the gases formed in one second would pass, if free to do so, in 0·401 seconds, and the air enter in 0·297 seconds; while at 872° the gases would pass in 0·399 seconds, and the air enter in 0·247 seconds; it can, therefore, be safely assumed, that at 872°, more air could be made to enter and more gases pass away, in a ratio compounded from these figures; that is, as 0·401+0·297 : 0·399+0·248 : : 1·08 : 1·00. In other words, about 8 per cent. more coal would be burned upon the grate if the chimney were heated to 872°, than if it were heated to 450°. Making a little allowance for the friction upon the reduced length of the boiler, the rate of combustion would be 13 lbs. of coal per square foot of grate per hour, in place of 12 lbs. This rate of combustion would, of course, increase the volume and velocity of flow of the gases, and each two feet length of boiler, at which the table of temperatures has been estimated, would become two and one-twelfth feet, and the gases would then, at the distance of sixteen feet

from the fire bridge, have the same temperature as they would have had with the primary velocity at the distance of fourteen and three-fourths feet. By interpolation, it will be found that this new temperature for the chimney will be 872°, as has been assumed.

The combustion of 13 lbs. of fuel, at 13,500 units, will give 175,500 units, the loss of heat up the chimney from the escaping gases at 872° (= 812°, above original temperature of 60°) = 10,556°, lbs. of coal × 5·94 (= specific heat of the 25 lbs. of gases to each pound of combustible) = 62·703 units; leaving 112·797 units as the result from the 13 lbs. of fuel. On the other side the combustion of 12 lbs. of fuel, at 13,500 units, will give 162,000 units; the loss of heat from escaping gases at 450° (= 390° above original temperature of 60°) = 4680°, lbs. of coal × 5·94 = 27,799 units; leaving 134,201 units. From this it appears that the removal of 20 feet from this boiler would impair its heating capabilities, *per square foot of grate*, a little less than 16 per cent.; and that thus the reduction of the total heating surface to 50 per cent. would be accompanied by the reduction of capability to 84 per cent.

The two suppositions, which produce this result, are: first, the giving out of one-fourth the entire heat, at the fire place; and second, the acceleration of maximum rate of combustion from 12 to 13 pounds per square foot of grate per hour. As to the first of these, no positive authority exists. Peclet ("Traité de la Chaleur") estimates one-half the heat of a fire, from some kinds of fuel, as what is given out by immediate radiation, when surrounded by surfaces of absorption, but his experimental furnace was a toy. Many imperfect experiments on a larger scale, have given for fire box boilers a temperature, for the gases back of the bridge, which would be equivalent by calculation, to the abstraction of rather over one-third of the heat of the fuel for this kind of surface; and it is thought by the writer that the assumption of one-fourth, is certainly *within* the actual dispersion of heat, for under-fired boiler furnaces. While the writer concludes, therefore, to adopt this ratio, he calls attention to it, that any reader may, for himself, value the effect of either increase or decrease in this proportion. As to the acceleration of rate of combustion by increased draft, the figures taken are unquestionably within the rate of actual occurrence. The largest resistance to the draft, is the passage of air through the coals upon the grate; and the assumption that there exists an equality of *resistance* between the coal passage and

the flue passage, on which this increase of coal burned from 12 to 13 pounds is founded, is as favorable to the *least* rate of combustion (or 13 pounds) as possible. [If the rate of combustion for the short boiler were taken at 14 lbs. (which would presume that about two-thirds of the surplus of velocity of the entrance of air was expended in meeting resistance of the coal passage), the heating capabilities of a square foot of grate of the short boiler, would become about 12 per cent. less than what belonged to the long boiler.]

The relative capabilities here estimated will not be materially changed if the heat proceeding from each pound of fuel is varied; that is, if in place of 13,500 units, (12,000 units), or a less number be taken as the bases; nor would a less rate of consumption than 12 lbs. materially change the result, after the same course of figures is gone through; and in the same way the adoption of a smaller supply of air than 25 pounds to each pound of fuel, will only alter the calculations, without materially affecting the final ratios.

Recurring to the figures again: there are found 3375 units to each pound of coal, as given out in the fire box in any case; and with the short boiler, where the escaping gases pass off at 872°, there is left 5302 units to be taken up by the 16 feet length (behind the grate) of heating surface; while for the long boiler, with the escaping gases at 450°, there is left 7808 units to be taken up by its 36 feet of length; and for the 13 pounds of combustion, on a square foot of grate, there is 64,285 units expended on 16 ft. long, in one case; and 93,700 units on 36 feet long in the other.

With this data it will be possible to tabulate the result for boilers of other proportions of grate to heating surface; noticing the following qualifications: first, the quantity of coal burned per square foot of grate is taken at 12 lbs. This quantity is a proper assumption for the given chimney for the amount consumed in the middle part of a grate surface (as a maximum); but it can be taken as a practical constant of allowance, that a deduction of two square feet of surface, from any total dimension of rectangular grates (of ordinary grate bars) should be made, to compensate for imperfection of cleaning out at the sides and corners. Thus the 4 ft. square grate, supposed as the basis of this inquiry, becomes practically but 14 square feet of efficient area, in lieu of 16 square feet; or to make the combustion equal to the quantity taken, the grate should be increased in width (or length) to 4 ft. 6 in., giving a total of 18 square feet of surface, of which only 16 square feet

come into general average use. This last proportion (of 4 ft. 6 in. width) is, in fact, that generally used in setting a four feet plain cylinder boiler, although open to the grave defect of vertical sides for the fire place. It may be well to observe also that the efficiency of a grate falls off rapidly with increase of length, when over 5 ft. long; and in some degree, when over 4 ft. long. A second qualification is to be made in the chimney or flues cross area. The resistance of passage of the gases in the chimney and flues, is mainly that of the elbows and alterations of section, while it is partly that of friction against the sides. The efforts of writers upon the subject of dimensions of chimneys, have been directed towards *estimating* the value of these resistances, and reducing them to some ratio of the force of draft induced by the heated gases. Owing to the variety of conditions and the divergencies of arrangement and construction, no satisfactory figures have resulted from this course of investigation; and the method offered in this paper is confidently presented as a general one, avoiding much abstruseness of calculation, which can be founded solely upon several assumptions with little basis. But the frictional resistance of long passages is a definite one, and bears a relation to length and to perimeter, and can, therefore, be approximately compensated for or equaled by some ratio or proportion of increase of area. It is proposed to do this by a *constant*, for all areas and heights of chimneys; and an investigation could be made to demonstrate the approximate correctness of the procedure, within the limits of the usual proportions of flues and chimneys for boilers; but such an inquiry would scarcely be interesting reading. If there be added to the cross sectional area of a square chimney of any size or height, one-half a square foot, the resistance of friction will have been reduced to a practical equality of ratio, and the *effect* of the draft due to the height, may be taken as independent of the different surface frictions. The actual area of chimney flue then appertaining to the 40 and 20 ft. boilers, which have been made examples, becomes 1·83 square feet, in place of the 1·33 square feet, on which the figures were based. These two corrections are both in the same direction, and in one way the constant of half of a square foot of chimney may be said to supply the area needed for the constant of two square feet of grate. The effect of the constants upon the final ratios is, however, very different.

TABLE

of evaporative capability of one square foot of grate surface of, and of evaporative efficiency of the fuel burned, under plain cylinder boilers; with surfaces in different proportions to their grates and chimneys—example of 70 ft. high chimney with chimney section = one-twelfth grate area—13,500 units of heat, assumed to be produced by the combustion of one pound of anthracite coal, (= 15,000 total, less 10 per cent. for imperfect combustion).

Whole length of boiler exposed to the fire.	Length of boiler behind the fire bridge.	Quantity of coal burned per square foot of grate.	Temperature of gases escaping up the chimney.	Units of heat imparted to the boil'r	Ratio of *capability* of one sq. ft. of grate, taking the capability of the 40 ft. boiler as unity.	Ratio of *efficiency* of one pound of coal burned upon the grate, taking the efficiency of the 40 ft. boiler as unity.	Ratio of total heating surface p'r sq. ft. of grate, assuming 1·6 diam'er of shell exposed. Grate = to unity.
40	**36**	**12·0**	**450°**	**134,200**	**1·00**	**1·00**	**16·0**
38	34	12·1	470°	133,180	0·99	0·98	15·2
36	32	12·2	511°	131,960	0·98	0·97	14·4
34	30	12·3	546°	130,520	0·97	0·95	13·6
32	28	12·4	583°	128,840	0·96	0·93	12·8
30	26	12·5	623°	126,900	0·95	0·91	12·0
28	24	12·6	666°	124,680	0·93	0·89	11·2
26	22	12·7	712°	122,160	0·91	0·86	10·4
24	20	12·8	761°	119,320	0·89	0·84	9·6
22	18	12·9	815°	116,240	0·87	0·81	8·8
20	**16**	**13·0**	**872°**	**112,700***	**0·84**	**0·78**	**8·0**
18	14	13·1	934°	108,780	0·81	0·74	7·2
16	12	13·2	1000°	104,460	0·78	0·71	6·4

* Reduced 97 units in preparation of table.

Although the investigation contemplated by the title of this article is finished by this table, the relation of cross area of chimney to grate has been shown to be involved in the discussion; and from the data given and accepted as the basis of the calculations, it is easy to tabulate results of even more general value than those pertaining to the relations of heating to grate surface, etc.; and the following table gives the area of cross sections of chimneys, for stationary boilers of from 6 to 40 square ft. surface, with square, or nearly square, grates; and with chimneys from 25 to 140 ft. in height; with the maximum quantity of coal the grates will burn, under best conditions, with such chimneys; and the nominal horse power of the grates calculated for 0·55 square foot of grate per horse power (after deducting 2 square feet of grate surface as inoperative).

TABLE.*

Actual surface of grate.	Maximum quantity of coal burned per hour, at 12 lbs. per foot (less 2 feet of actual area).†	Horse power at 0·55 sq. ft. grate (less 2 ft.)‡	PROPER SECTIONAL AREAS OF CHIMNEYS for grates of various surfaces. Height of chimney in feet.										
			25	30	40	50	60	70	80	90	100	120	140
6	48	7·07	1·06										
7	60	9·09	1·20	1·14									
8	72	10·91	1·34	1·27	1·16								
9	84	12·73	1·48	1·39	1·27	1·2							
10	96	14·54	1·62	1·52	1·39	1·3	1·23						
12	120	18·18	1·90	1·88	1·61	1·5	1·41	1·34					
14	144	21·81	......	2·03	1·82	1·7	1·59	1·50	1·44				
16	168	25·45	......	......	1·93	1·9	1·77	1·67	1·60	1·53			
18	192	29·09	......	......	......	2·1	1·96	1·84	1·75	1·68	1·62		
20	216	32·72	......	......	......	......	2·14	2·00	1·91	1·83	1·76	1·65	
22	240	36·36	......	......	......	......	......	2·17	2·07	1·98	1·90	1·78	1·66
24	264	40·00	......	......	......	......	......	......	2·22	2·12	2·04	1·91	1·78
28	312	47·27	......	......	......	......	......	......	......	2·27	·32	2·16	2·01
32	360	54·54	......	......	......	......	......	......	......	......	2·60	2·42	2·25
36	408	61·81	......	......	......	......	......	......	......	......	......	2·67	2·47
40	456	79·08	......	......	......	......	......	......	......	......	......	......	2·71
1 ft. grate without constants.			0·1400	0·1278	0·1107	0·0990	0·0911	0·0837	0·0783	0·0738	0·0700	0·0639	0·0582

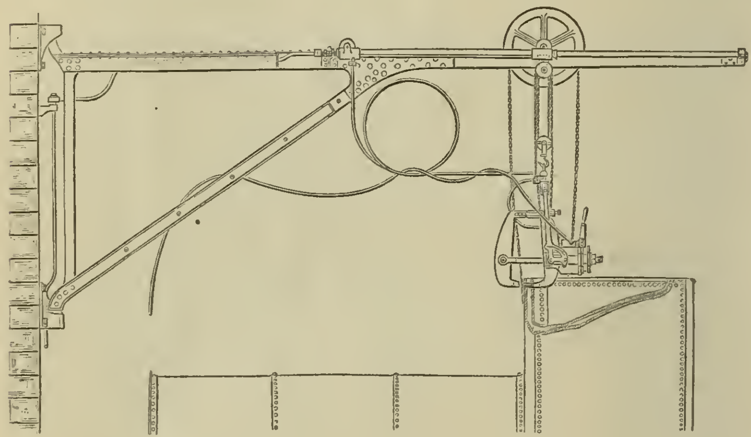
* The figures given in this table can be referred to coal burned, when less quantities than 12 lbs. per square foot are burned, by taking the actual quantity burned in the second column, and finding the corresponding area of chimney, independent of the grate altogether.

† The quantity of coal *shoveled upon the grate*, in yielding the nominal horse power assumed, will have been 10-12ths that given as maximum in this column.

‡ This ratio of 0·55 square foot of grate is supposed to represent the evaporation of one cubic foot (59·48 lbs.) of water from and at 212° per hour, or 57,458 units of heat, and consequently only 104,447 units of heat are assumed to result from the fuel burned on each square foot of grate. The maximum figures given in the table for the 40 ft. long boiler, burning 12 pounds of coal per hour, is 134,200 units, a figure 22·2 per cent. in excess of this assumption as data for horse power. This difference can proceed either from less perfect combustion or less active firing—probably the latter; and if so, the average combustion will have been taken at 9½ lbs. of coal burned per square foot of grate, or about 10 lbs. of coal shoveled into the fire per hour—a supposition not far removed from the desirable rate, from which should be estimated the production of a horse power, with certainty and ease, with the use of any kind of coal.

TWEDDELL'S PORTABLE RIVETTER.*

The accompanying illustration shows the arrangement of Mr. Tweddell's well known portable hydraulic rivetter, which has been at work now for some months at the London and Northwestern Railway locomotive shops, at Crewe. Mr. F. W. Webb has for some time been



considering the best method of doing such portions of the rivetting of locomotive boilers as cannot be done in the fixed rivetters, and is, we understand, well satisfied with the working of the above machine. The arrangement is so simple that not much description is needed. An ordinary swing crane has attached to it a hydraulic sleeve or outer cylinder, which is moved along a fixed tube or pipe by means of a pinion worked by a sprocket wheel, this pinion gearing into a rack attached to the crane. The water, which is supplied under a pressure of 1500 lbs. per square inch from one of Tweddell's differential accumulators, is taken from the main laid along the shop wall, and thence up the centre on which the crane radiates. Thus any motion caused by swinging the crane is reduced to a minimum, and a swivel joint almost frictionless causes no twisting strain to be imparted to the pipe. After leaving this joint the pipe is led along the jib, as shown. There is a communication between this fixed pipe and

* This claim for superiority of "hydraulic" pressure rivetting is not warranted in fact, as against other pressure rivetting, but fully attaches to the inferiority of *hammer* rivetting, either by hand or by steam.—Ed. of the Journal.

the larger one which slides on it, and this sleeve or sliding tube is balanced. A very similar arrangement is used by Mr. Webb in some of his rolling mill patents.

The rivetter is hung from one end of the sliding sleeve, and the pipe conveying water to it from the other. The water is then, by means of a simple frictionless universal joint, led into the machine, which is free to turn completely round in a horizontal plane. The raising or lowering is done by Weston's blocks, and the angle of the machine jaws can be altered from vertical, as shown, to horizontal, by the quadrant in the suspending gear. It will be seen that there is no strain on any of the pipes, and the great difficulty in transmitting the pressure to a rivetter, or other machine in a portable form, is overcome.

The saving in cost of rivetting by this method over the present mode is about four-fifths, and the quality of the work is, like all that done by hydraulic pressure, excellent. A similar machine to this one is adapted to the rivetting up the firehole door rings, and another machine is under consideration which will rivet on the manhole and steam domes. It can then be said that practically every rivet in a boiler will be machine closed, since the machine illustrated this week also rivets on the smoke box tube plates.

The travel of the machine at Crewe is 6 ft. from outer end of the jib inwards; it is also easily arranged by putting the inlet pipe where the rivetter is suspended and the rivetter to where the pipe coupling is, for the rivetter to cover another 6 ft. inwards, in all 12 ft., without any more connections to the main. The whole apparatus is easily lifted by the overhead traveler to other wall brackets, and thus one crane can work a whole shop.

A similar plan is being used for rivetting girders, the crane being of a rougher design, or in many cases the hydraulic gear is easily attached to existing cranes. Girders and other work are done with this machine at Crewe, and very good work by two similar machines is now being done in the large girder and boiler works at Sir W. G. Armstrong's, Elswick, and elsewhere.—*Engineering*, Feb'y 11, 1876.

Engraving on Iron and Steel.—As the result of very many experiments, Professor Kick recommends the following solution for engraving iron and steel, to show the grain, etc.:—Equal parts of hydrochloric acid and water, with a trace of antimonial chloride.

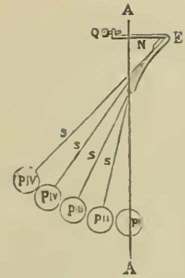
THE RESULTS OF SOME EXPERIMENTS WITH HUYGEN'S PARABOLIC PENDULUM FOR OBTAINING UNIFORM ROTATION.

By R. L. J. Ellery, F. R. S., F. R. A. S., etc.*

In the course of some experiments I made about two years since with the view, if possible, of obtaining more uniform rotation for our barrel Chronographs than had hitherto been secured, I was induced to try Huygen's revolving Parabolic Pendulum, which appeared so perfect theoretically, that I surmise as the reason it had not been more generally adopted that there must be some great practical difficulty pertaining to the application of the principle.

I was somewhat surprised too, on looking into the literature of the subject, to find so little information; and in the books within my reach in Melbourne no record of any experiments or precise trials of this kind of pendulum for securing uniform rotation. I had, therefore, nothing to guide me in my experiments except the bare principle. The earlier results I obtained were so unpromising that my idea that there must be some fatal practical difficulty in the way was strengthened. Eventually, however, I succeeded in obtaining results, and under trying tests, which satisfied me that the pendulum would, with moderately precise workmanship and careful adjustment, become an almost perfect Governor where the variations of force are not greater than we generally have in chronograph trains, or, indeed, in well-constructed and balanced Equatoreals; and in two Chronographs which I had constructed for the Transit of *Venus* observations and which were controlled by parabolic pendulums, the rotation of the barrels were practically uniform, even when such a variation of the driving weight was made as to produce a difference of 20° in the arc of the rotating pendulum. When I say *practically uniform*, I mean that, on a barrel rotating once in a minute for two hours and a half, *all similar second marks* were in an absolute straight line, and that with a fine drawing pen and a straight edge a line could be drawn accurately bisecting each second mark; in other words, its secondary rate was not a tenth of a second in two hours. As the principle of Huygen's Parabolic Pendulum may not be generally known among our members, I would beg to refer to these diagrams:—

*From the monthly notices of the Royal Astronomical Society, December, 1875.



Let A A be a vertical axis of rotation which can be driven by clockwork acting at the top or the bottom of the axis; from this axis a pendulum P is suspended in such a way that when it hangs vertically the string S lies wrapped over a curved surface E, which forms part and parcel of the vertical axis. This curve is the evolute of a parabola, whose distance from vertex to focus is half the length of the required pendulum. Now let the axis revolve and the pendulum will fly out from its vertical position, more or less, according to its weight and the driving power; the arc described by the pendulum, as it increases its distance from the vertical, will be a parabola, by reason of the string gradually unwrapping from the evolute E. Now, from the properties of the parabola, it follows that the vertical distance between the centre of rotation of the pendulum P and the intersection of the string S with the axis of rotation of the pendulum will remain constant, and therefore that the length of the pendulum remains constant at whatever arc it may rotate.

To practically secure these conditions it is necessary, first, that the evolute shall be properly and precisely made, and secondly, that it shall be so adjusted that the axis of the evolute and involute shall be coincident with the axis of rotation.

The pendulums I had constructed are *half seconds*, that is, rotating once in a second. They are suspended in a hard gun-metal frame, pivoted at top and bottom, the lower pivot resting on an end jewel, the upper pivot supported by a strong cast iron gallows bracket, and it is driven by a contrate wheel in the clock train engaging into a pivot at the lower end of the frame. The frame is open, in the form shown in the right hand figure, to allow of the middle part of the axis of rotation being clear for the evolute and the pendulum string or rod. The evolute is fixed at M, and is capable of adjustment at right angles to the axis of rotation by a screw Q, the proper position of the curve in the other direction being practically secured by careful workmanship, more especially in the construction of the evolute itself. The pendulum consists of a spherical bob, weighing about 2½ lbs., on a steel rod about one-tenth of an inch thick, and suspended by a long and *exceedingly thin* steel spring secured to the top of the evolute at N. The regulation of the length of the pendulum is done in the or-

dinary way by a nut at the bottom of the steel rod. The Governor thus made with ordinary care and workmanship is by far the best of any I have had experience of, and has furnished results better, I believe, than any others used with chronographs; at the same time it is simple and inexpensive. In the course of my experiments I found it quite necessary to use the most flexible suspension possible, and the thinnest steel spring made for French clock pendulum springs appears to answer well—it is not liable to twist unless the pendulum is started or stopped suddenly, and this is prevented by a guide for the bottom of the pendulum rod. To get the proper position of the evolute:—If the time of rotation increases with an increase of arc, in other words, if it revolves slower for increase of arc, the axis of the evolute is beyond the axis of rotation, reckoning from the centre of oscillation of pendulum (that is, it is too far away from pendulum bob); and it is too near if it revolves more rapidly for increase of arc. The adjustment is somewhat tedious, more especially because for every alteration, however slight, of the evolute, a large alteration of the length of pendulum is requisite—but it is easily done with a barrel chronograph by increasing and diminishing the driving power and noting the effect, on the rate, of increased and diminished arcs of pendulum. The screw which adjusts the evolute should be moderately fine, as the final touches necessary to get accurate performance will be found very small. I found a good deal of trouble in the course of my experiments from small particles of dust getting between the curve and spring, and it will be found quite necessary to protect the pendulum from this source of imperfect performance.

I had an opportunity of testing one of these chronographs in the presence of Professor Harkness, of the Washington Observatory. It was allowed to go for about an hour, then the weight was doubled for half an hour, and subsequently halved—the arc of the pendulum varying from 10° to 33° under these changes, but the *lines of seconds* on the barrel were quite undisturbed, and a fine straight line could be drawn so as to bisect every similar second mark. Professor Harkness was somewhat astonished and pleased with the result. I showed one or two sheets marked by this chronograph to Sir George Airy, Mr. Christie, Mr. Dunkin, and Captain Tupman, and I intended to show them at the meeting of the Society, but I unfortunately mislaid them. I have no doubt, however, these gentlemen will remember the exceeding precision with which the sheets were marked.

It may be said, however, that such great precision is unnecessary, especially in astronomical chronographs, and that any of the ordinary means of obtaining moderately uniform rotation are sufficient for astronomical purposes. I shall be in a great measure inclined to agree with such an opinion, but not altogether, for these reasons. This Governor, which gives nearly perfect results, is simpler and cheaper than nearly all those which only aim at very moderate accuracy; and again, any one who has had much to do with *reading off* chronograph sheets or fillets will, I am sure, agree with me that *time is saved enormously* where *a scale* of minutes and seconds can be applied to the register, which can only be done with confidence where the rotation has been uniform. In an Observatory where much transit work (especially in Zone-observing) is done with aid of the chronograph, as at Melbourne, any means by which *reading off* can be expedited is of much more value than many would be inclined to imagine. Again, a simple means of obtaining accurately uniform rotation will be of great value in driving siderostats, and in many physicial and physiological experiments; and I do not imagine there would be any great difficulty in applying this method to governing the driving apparatus of Equatoreals, the uniform motion of which, I believe, yet remains a thing to be desired.

I have on the table an apparatus, a kind of Morse's telegraphic register, governed by a parabolic pendulum, which will illustrate my description. It is devised to draw a paper fillet over rollers with great uniformity for chronographic purposes.

Cornish Pumping Engines.—The following is extracted from the *Mining Journal* of January 29th, 1876: The number of pumping engines reported for December is 17. They have consumed 2076 tons of coal, and lifted 15,600,000 tons of water 10 fms. high. The average duty of the whole is, therefore, 50,800,000 lbs., lifted 1 foot high, by the consumption of 112 lbs. of coal. The following engines have exceeded the average duty.

Crenver and	Wheal Abraham	—Sturt's 90 in.	Millions	59·7
Ditto	Ditto	—Pelly's 80 in.	"	52·7
Ditto	Ditto	—Willyams' 70 in.	"	78·4
Dolcoath—85 in.			"	59·4
West Basset—Thomass' 60 in.			"	54·5
West Tolgus—Richard's 70 in.			"	52·4
West Wheal Seton—Harvey's 85 in.			"	57·2

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.

From the *Chemical News.*

[Continued from Vol. ci, page 213.]

The three last named methods may be considered as adapted for industrial purposes. As the peroxide of hydrogen does not solidify at — 30°, its solutions may be concentrated by cooling them below 0°, and allowing the water to freeze out. For this purpose Houzeau makes use of the apparatus of Carre.† A great difficulty in the way of the commercial preparation of peroxide of hydrogen lies in its instability. This substance requires to be preserved in well-closed vessels and in acidulated solution, and even thus it requires great caution. Wood-charcoal and certain oxides and metals, especially silver, gold, and platinum in a state of fine division, decompose it by mere contact.

That it is a powerful oxidizing agent, and that it even in the cold converts arsenious into arsenic acid, sulphide of lead into sulphate, and the lower oxides of manganese, iron, cobalt, barium, strontium, and calcium into the highest oxides of these metals, and that it once completely oxidizes arsenic and other elements, is not remarkable. But the more interesting and surprising are the observations of Thénard, extended and explained by Brodie in 1850, and shortly afterwards at Schonbein, according to which the peroxide of hydrogen acts not merely as an oxidizer, but as a powerful reducing agent; that it converts iodine into hydriodic acid,

$$I + H_2O_2 = 2HI + O_2,$$

* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† Houzeau *Monit. Scient.*, 1868, 175.

that it separates metallic silver from silver oxide,

$$Ag_2O + H_2O_2 = Ag_2 + H_2O + O_2,$$

and reduces peroxide of manganese to manganous oxide,

$$MnO_2 + H_2O_2 = MnO + H_2O + O_2.$$

In these reactions two atoms of oxygen coalesce to one molecule, which explains this strange phenomenon. At times, peroxide of hydrogen acts almost simultaneously as an oxidizer and a reducer. Thus it converts chromic acid, CrO_3, transitorily into perchromic acid, which is very soon resolved into chromic oxide and free oxygen. If we, therefore, add to peroxide of hydrogen a few drops of a solution of chromate of potash and a little hydrochloric acid, and shake up with ether, the latter is colored a deep blue by perchromic acid, but soon (especially if no ether is present) oxygen escapes and green solution of chloride of chromium remains. Similarly both actions appear simultaneously when solutions of ferrous sulphate and indigo are mixed with peroxide of hydrogen. The ferrous oxide is transitorily peroxidized and then again reduced, whilst the oxygen is transferred to the indigo and decolorizes it.

By these effects of oxidation and reduction, both of which it displays in the highest degree, the industrial sphere of the peroxide of hydrogen is marked out. These effects, although mutually antagonistic, answer the same purpose for a certain practical operation, *i. e.*, bleaching sulphurous acid and zinc powder, powerful reducers, as well as chlorine and ozone, powerful oxidizers, are all used as bleaching agents. How much the rather can this function be assigned to peroxide of hydrogen?

Thénard, on bringing peroxide of hydrogen into contact with his tongue, in order to ascertain its taste, found that it was whitened. The cuticle was also blackened, and at the same time a violent itching was excited. Litmus paper without any previous reddening was at once decolorized, as was also turmeric paper.

In 1863, Chevreul* undertook comparative experiments on the bleaching power of hydrogen peroxide. Its concentrated solution speedily turned syrup of violets, green, oxygen being set at liberty. For the following experiments dilute color solutions were used

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* Chevreul, *Comptes Rendus*, lv, 735.

—namely, syrup of violets, tincture of litmus, extract of peach wood, and extract of logwood. The results were as follows:

Time.	Violets.	Litmus.	Peach Wood.	Logwood.
10 mins.	Imperceptible.	Slight bleaching.	Change to rose.	——
24 hrs.	Complete bleaching,	Almost complete bleaching,		Turns yellow.
80 hrs.	Complete bleaching of all the solutions.			

Decolorization is therefore effected less rapidly by peroxide of hydrogen than by chlorine. Tessié du Motay and Maréchal* mention it as one of the agents which they propose for bleaching tissues, which, after treatment with permanganate of potash, they recommend to be steeped in a solution of peroxide of hydrogen. But it had been much earlier applied as a bleaching agent by Thénard† himself for a particular purpose—namely, for restoring old oil paintings and drawings. White lead in old paintings, which has become blackened by the gradual action of sulphuretted hydrogen, is converted into sulphate of lead by dilute solutions of peroxide of hydrogen, and thus restored to its primitive color. A fine drawing by Raffaelle, with superimposed white which had become spotted with black, was completely cleansed by a solution which contained at most five or six times its volume of available oxygen, and the paper did not suffer.

A peculiar, hitherto secret, application of this bleaching agent has been recently made public by A. v. Schrotter.‡§ During the last few years, bottles labeled "Eau de Fontaine de Jouvence, golden," and containing about 140 c. c. of a colorless liquid, have been sold by perfumers in great cities. The price demanded is about 20 francs, and to them, as it appears, is due that offensive blonde shade of hair which holds an intermediate place between ash gray and bright yellow, and attracts the attention of the spectators and the curiosity of observers by its *piquante* unnaturalness. According to Schrotter this secret nostrum is merely a solution of hydrogen peroxide, made stable

* *Bull. Soc. d'Encouragement*, 1867, 472. Dingler, *Polyt Jour.* cxxc (?) iv, 526.

† Pelouze and Frémy, *Traité de Chimie*, 1861.

‡ *Berl. Chem. Ges.*, 1874, 980.

§ From the correspondence of the *Chemical News*, January 14, 1876, it appears that the composition of this liquid was first published by Dr. Chas. A. Cameron, in the *Dublin Medical Journal*, November, 1869.

by copious dilution, and by addition of a small quantity of acid—apparently nitric acid. According to Schrotter's careful examination it contained 6 volumes of available oxygen; 1000 grms. of the liquid would therefore contain 8·6 of available oxygen, or 18·3 of peroxide of hydrogen. As may be imagined, however, in case of an easily decomposable body, the bottles do not all contain solutions of equal strength. An examination conducted in the laboratory of the University of Berlin, showed, in 1 volume of the solution 9·4 to 9·8 vols. of available oxygen, corresponding to 13·6 grms. O, or 28·9 grms. H_2O_2 per liter. A bottle costing 20 francs yields the purchaser 2·5 to 4 grms. of this substance in solution, and effects its purpose completely, though slowly, within four to six days, thus strikingly illustrating the great efficacy of peroxide of hydrogen. The name of the perfumer who understands how to speculate so successfully upon the purses of his fair contemporaries, and who deserves to be known to posterity, is E. H. Thiellay, of London.

Perhaps Mr. E. H. Thiellay has unintentionally become the founder of a manufacture of peroxide of hydrogen which may have worthier applications in the future. Perhaps he may not be the first or the only hair bleacher, as appears from the following document. What von Schrotter revealed to the public was previously known to the initiated. Thus it appears from a letter of M. Schering, of the Council of Commerce, dated Berlin, July 3d, 1874, in which occurs the following passage:—

"The bleaching of hair, feathers, etc., by means of peroxide of hydrogen has been found practicable, the greatest difficulty being the ready decomposability of the material. In England and France it is prepared and sold for this purpose in quantity under the names 'Golden Hair Water' and 'Auricome.' In my establishment it is often inquired after for the same purpose." Mr. J. Williams, of the firm Hopkin and Williams, of London, makes a similar statement in letters of July 20 and 27, 1874. By peculiar precautions, however, he is able to prepare permanent solutions of peroxide of hydrogen containing 10 to 20 volumes of available oxygen (3 to 6 per cent. by weight of H_2O_2). The weaker solution, which is said to keep for months without change, is sold at 8s. per kilo., in larger quantities at 6s. The stronger solution is sold at double the price. The amount of oxygen in Thiellay's solution, as determined in the Berlin labor-

atory, agrees tolerably closely with the weaker of these preparations, and this may possibly be its true origin. As the bottle when the determination was made had been opened four weeks previously; as it was only half full and was merely provided with a common cork, the permanence of the solution may be considered sufficient for most purposes.

Peroxide of hydrogen would not be the first body whose industrial application commenced with trifles and gradually reached an unimagined extension. Nitrate of silver served first the vanity of the world as a hair dye long before its applications in photography. Schrotter* very rightly expresses the wish that peroxide of hydrogen might be generally accessible at a moderate price. Bottger,† and previously Geiger,‡ recommend its introduction into the pharmacopœia. That for medicinal purposes it is preferable to oxygen, ozone, or ozone water (!) is manifest. Whilst ozone only bleaches ivory in the strongest sunshine of summer, there is no doubt but that peroxide of hydrogen would answer the same purpose even in the absence of light.

Progress in the Artificial Production of Cold and Ice. By Dr. H. Meidinger, *Professor in Carlsruhe.*

Concentrated cold in the form of ice acquired day by day a higher importance for industrial as well as for domestic purposes. Brewing on the Bavarian system, the preparation of "Lager beer," which, amongst us in Germany, at least, has nearly superseded all other kinds of beer, depends upon the prolonged maintenance of a temperature bordering upon freezing point. The confectioner has no other practical means of producing a degree of cold from — 12° to — 18°, as required in the preparation of ice creams. The physician often employs the cold of ice both externally and internally as an absolutely indispensable remedy. The butcher and the hotel keeper can scarcely dispense with this means of preserving meat. In the domestic sphere ice has become formally established, at least in large cities, where it can always be obtained at a cheap rate, and to those who have become accustomed to its use, it appears a necessary agent for preserving food and cooling beverages during the warm season.

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* Von Schrötter, see above.

† Böttger, *Polytech. Notizblatt.* 1873, 13.

‡ Geiger, *Lehrbuch der Pharmacie* aufl. bearb., v. Liebig, i, 213.

In chemical manufactures ice has also found various applications in the crystallization of salts, or, to speak in more general terms, in the separation of dissolved substances by means of cold. In proportion to the growing consumption, we see increasing quantities of ice stored up every winter. An extensive system of transportation has been arranged for conveying ice from the more northern and colder parts of the earth to regions nearer the equator. North America especially ships ice in astonishing quantities in all directions, even to Central and South America, to the West Indies and to India. Ice from Norway is sent to England and the German ports on the North Sea. In mild seasons, such as 1862–63 and 1872–73, ice from the glaciers of the Alps was sent down the Rhine in entire trains.

Science has shown, however, how to prepare the important requisite artificially. The first attempts at the manufacture of ice on the large scale took place between 1850–60; but this branch of industry has since been much extended. Even in regions where the winter is, as a rule, cold enough to permit ice to be stored up in quantity, *e. g.* in Germany, it has often been found remunerative to construct machinery for its artificial preparation, or in general terms, for the production of cold. Manufacturing establishments of this kind may be seen in various places in full activity, and after the mild winter of 1872-73, the demand for machine-made ice could scarcely be met.

The London Exhibition of 1862, introduced the ether and ammonia ice machines. A third system has since been added, the air ice machine, which has not yet reached perfection, since peculiar difficulties interfere with its practical execution. The theories of these machines have been already explained, so that there is no difference of opinion as to their capabilities and their relative merits. A series of proposals have also been made for the production of cold by other agencies, which have hitherto produced little or no practical result. We will endeavor to describe the development which the question has taken in all its branches down to the present day.

The science of physics reveals three procedures by which a reduction of temperature can be effected, ice being the result if the cooling is sufficiently intense and is applied to water. The methods in question are:—The solution of solids (salts); the spontaneous evaporation of liquids; and the expansion of aeriform bodies. Each of these methods has met with practical applications; the first mentioned or solution process for reducing the temperature of small mass in simple

apparatus not acting continuously; the two others, evaporation and expansion, for the uninterrupted production of ice in complicated machines.

1. *Cold obtained by Solution.*

Every mixture of substances in proportion as it produces, during solution, the greatest depression of temperature in its own mass is called a freezing mixture. Various mixtures of this kind have long been known, and may be found described in all text books of physics. The best known and most commonly applied both in domestic and technical affairs pre-supposes the presence of ice. It consists of 3 parts of ice and 1 of common salt, which dissolve each other, whilst the temperature falls to —21°, the freezing point of a concentrated solution of chloride of sodium. The solution of a part only of the mixture is requisite to produce this low temperature in the entire mass. Not till heat penetrates from without into the mass does a further melting take place, the temperature remaining the same. Consequently the above degree of cold may be kept up till all the ice has been melted with the salt. It is necessary, however, to keep the mixture continually agitated. This snow and salt freezing mixture is used in preparing ice creams, for which a temperature of about —12° is required. As the essential point here is the congelation of water and the other substances present may be neglected, as far, at least, as their specific and latent heat is concerned, it is easy to calculate what weights of ice cream may be prepared with a known quantity of freezing mixture.

The freezing apparatus of the confectioners consists of a tin vessel for receiving the ingredients, placed in a larger bath of wood or tinned copper. The interval is filled with ice and salt, which are constantly stirred that the mutual contact of the two may be perfect. If this is neglected, the salt, after a portion of the solution has been formed, sinks to the bottom and ceases to act upon the ice. Since about 1865, a freezing apparatus for domestic use has been introduced from Paris, arranged as follows: A cylindrical pewter vessel with double sides is fitted in the middle of a jacket with two pivots, which rest upon two supports fixed in a block of wood. One of the pivots is prolonged so as to form a handle which serves to keep the cylinder in continual rotation. The two plane ends of the cylinder are discs of wood, which are pressed upon the cylinder by a peculiar arrangement, india rubber rings being used to preserve complete tight-

ness. The interval between the double sides of the cylinder is filled with a bad conductor of heat. A cone of pewter is introduced into the interior, and can be opened on one side to receive the materials for the ice cream; the annular interstice is filled with salt and ice, which are introduced from the other side. The lid is put on, and the handle is turned for about five minutes. The lid of the cream receiver is then taken off, and the matter which has become deposited on its inner sides is scraped off with a spatula and stirred up with a still unfrozen residue to a butter-like consistence. The apparatus is closed again, turned for five minutes, opened again, and the contents stirred up as before—an operation which is repeated a third time. In a quarter of an hour the ice cream is ready. The apparatus acts satisfactorily, but it is troublesome and rather costly.

Dr. H. Meidinger has constructed a simplified machine to which the way has been paved by the observation that a concentrated solution of salt melts ice, producing, if the concentration be preserved, the same low temperature as does the action of solid salt upon ice.* The machine consists of the following three parts: —A cylindrical vessel (cooler) with double sides quite open at the top; secondly, a conical tin vessel (freezer) of about half the diameter of the former, reaching down nearly to its bottom and furnished above with a firmly connected covering plate, which rests upon the top of the cylinder and fits it tightly like a lid; lastly, an annular strainer-like vessel (the salt holder), which is let down into the space between the cylinder and the freezer at about half the depth of the former. The cylinder is charged about half full of pounded ice, upon which is poured a concentrated solution of salt; the strainer filled with salt is then let down, and lastly, the freezer containing the materials for the ice cream is forced in and is in complete contact with the freezing mixture over its whole surface. The ice melts in the solution of salt, which, as it becomes diluted, dissolves more salt from the strainer and thus remains nearly saturated and capable of undiminished action upon the ice. The reduction of temperature throughout the apparatus is equable, and a mechanical movement of the vessel is not required. The needful agitation of the freezing ice cream is performed at intervals of five minutes, without any disarrangement of the apparatus. The machine is constructed by Messrs Beuttenmüller and Co., of Bretten, in an elegant form, fit for the table. Recently

* Meidinger, *Bad. Gew.*, 1872, Beil. No. 6. *Dingl. Pol. J.*, cciv, 409.

it has been applied on a larger scale in perfumery for the separation of fatty oils from spirit.

Freezing mixtures in which a fall of temperature is produced by the solution of salts in liquids have been latterly subjected to examination in various quarters, after different small ice machines for domestic use, adapted to their application, have been introduced into trade. Dr. Meidinger has drawn up a table of 16 mixtures* according to his own experiments. An abstract of this, comprising the most useful mixtures, is given below.

Mixture.	Fall of Temp.	Sp. Heat of Solution.	Sp. Gr. of Solution.	Loss of Heat units for 1 kilo. of Mixture.	Loss of Heat units for 1 liter of Mixture.	Quantities to be used for 120° C. Heat units. Salts. Kilos.	Water. Kilos.	Cost.†
1 Salt. 3 Ice.....................	27°	0·83	1·18	125	100	0·5	1·5	0·34 to 0·12
3 Sulphate of soda crystals 1 Conc. hydrochloric acid.	37°	0·74	1·31	55	74	2·7	1·8	1·0 to 0·6
2 Nitrate of ammonia. 1 Sal-ammoniac. 3 Water.	30°	0·70	1·20	42	51	3·0	3·0	7·6 to 6·8
3 Sal-ammoniac. 2 Saltpetre. 10 Water........................	26°	0·76	1·15	40	46	2·1	4·2	2·6 to 2·2
3 Sal-ammoniac. 2 Saltpetre. 4 Sulphate of soda cryst. 9 Water........................	32°	0·72	1·22	50	61	2 5	2·5	1·8 to 1·6

(To be continued.)

ELECTRICAL PHENOMENA.

The Alleged Etheric Force. Test Experiments as to its Identity with Induced Electricity.

By Prof. Edwin J. Houston and Prof. Elihu Thomson.

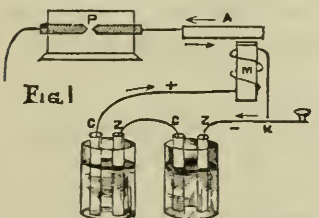
Since the experiments of Mr. Edison are still believed by some to demonstrate the existence of a force hitherto unknown, we submit the following considerations, together with experiments, which we believe to be crucial in establishing the identity of the supposed new

* Meidinger, *Bad. Gewerbz.*, 1868, 98.

† The cost is given in decimals of a shilling, assuming the shilling to be approximately equal to the German "mark."

force with inverse currents of induced electricity. The alleged necessity for the assumption of the new force being based on its asserted lack of polarity, we propose to show how two opposite phases of the so-called force may neutralize each other, thus conclusively establishing its polarity.

In order to show that, in Mr. Edison's experiments, inverse electrical currents must necessarily exist, notwithstanding the fact that the manifestations occur only at the *opening* or breaking of the circuit, we will discuss his typical experiment in detail. In Fig. 1 we have the well known arrangement for the production of the alleged new force. On the completion of the circuit, the battery current flows as shown by the arrows, and M becomes a magnet. On breaking the connection as at K, the so-called etheric force is manifested at the points P, in the dark box.

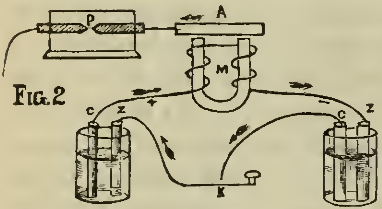


It is evident that the above embraces all the essentials of Mr. Edison's experiments. When a battery current flowing through a considerable length of wire, is interrupted by breaking contact as at K, a bright spark of appreciable length is seen at the break (K). This spark is due to the extra current, and indicates a great increase of electrical tension in the wire, the discharge occurring through an appreciable air space at K. It will be seen that the wire around the magnet is, at the moment of breaking contact, charged with electricity of considerable tension (extra current), positive or negative, according to the direction of the battery current. In Fig. 1, since the magnet wire is connected with the positive pole C of the battery, the charge in the wire will be positive, and a negative charge will be accumulated on the general conducting surface of the battery, which thus acts in part to condense the negative charge. This state of tension at once disappears on the discharge of the extra current. The extra current is not produced until the circuit is broken, and its discharge takes place when the wires have been appreciably separated, as shown by the spark. At every break, therefore, the wire surrounding the core of the magnet accumulates a static charge of considerable tension, which is rapidly discharged. This charge, acting by induction on the core of the magnet, induces in it, and in all metallic masses, in connection therewith, a flow or charge in one direction,

while the tension in the wire is increasing, followed instantaneously by a flow or charge in the reverse direction for the re-establishment of electrical equilibrium in the cores of the magnet, *consequent on the discharge of the wire itself*, the wire and the cores of the magnets bearing the same relations to each other as the inner and the outer coatings of a Leyden jar. Here, then, we have all that is necessary for the production of the so-called etheric effects, apparent non-polarity included.

In order to prevent the possibility of a charge of any tension remaining in the coils of wire on the interruption of the current, we arranged the following experiment: A battery of eight cells was divided into two sets of four cells each, as shown in Fig. 2. The sounder magnet *M*, used in this experiment, was connected as shown, *i.e.*, one end of the coils with the positive pole of the left hand battery, and the other end to the negative pole of the right hand one. An interrupter placed midway between the remaining poles of each battery furnished the necessary breaks, as at *K*. Under these conditions we could obtain no appreciable spark in the dark box at *P*. In this experiment the magnet is placed so as to occupy the exact middle of the circuit, one-half the wire in the coils being influenced by that part of the extra current which produces a positive charge, and the other half, by that which produces a negative one. When thus arranged the inductive effects of the extra current being equal and opposite, neutralize each other, and hence no inductive spark appears in the dark box *P*. In this experiment, thorough insulation of the batteries, key, and connecting wires, is necessary, in order to secure an equal division of the effective circuit.

FIG. 2



The absolute necessity for the equality of the two divisions of the circuit and of the neighboring conducting surfaces, in the above experiment, is shown by connecting any part of the circuit with a conducting surface, as, for instance, a mass of metal, or even the body of the experimenter, when sparks at once make their appearance at *P*. The mere approach of any person, *without* contact with any conducting surface near to any part of the circuit, or to either of the batteries, is followed by a similar result. In this connection it is evident that

any inequality in the metallic surroundings of the halves of the circuit is sufficient to cause irregularity in the results. So necessary is the *equal* division of the conducting surfaces, that even the use of an ordinary telegraphic key at *K* is sufficient to introduce unequal metallic surfaces into the circuit, and so derange the experiment, and we would therefore suggest that the breaks be made by the conducting wires themselves. If the battery be unequally divided, sparks are seen in abundance in the dark box.

To test the question of the polarity of the alleged new force, the following experiment was devised: The battery terminals were connected respectively with one end of the coils of the magnets *M* and *M′* which were exact counterparts of each other. The circuit was completed through the interrupter *K*, connected with the two remaining ends of the coils. Wires *a* and *a′* were provided for connecting the cores of the magnets with the dark box *P*, at pleasure. When the wire *a* was connected with *P*, sparks were seen in the dark box, in breaking the contact at *K*; similar sparks were seen where the wire from *a′* was alone connected. When *both a* and *a′* were connected with the dark box *no spark could be obtained.*

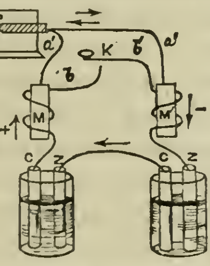


FIG. 3

In the foregoing experiment it is evident that the polarity of the extra current produced in *M* is the opposite of that in *M′*, representing, as they do, the positive and negative poles continued from the battery. Under these circumstances the induced charges in each core being opposite, neutralize each other, and no spark is seen. Since, however, contact of *a* or *a′* with *M* or *M′* singly gave all the so-called etheric manifestations, and that when both were connected no spark was obtained, *it is clear that in this experiment is presented unquestioned evidence of that polarity which has apparently been wanting, and which want has thus far furnished the only grounds for the assumption of the discovery of a new force.*

That the non-appearance of the spark at *P* was due to an exact neutralization of the two opposite phases of the "etheric force," is shown by bringing any conducting surface, as the finger, into contact with any part of the circuit, as at *b* or *b′*, when sparks at once appeared at *P*.

We found that it was not necessary to employ cores surrounded by coils of wire to produce the so-called etheric force. We note the following experiment: a hollow cylinder of non-conducting material as a test tube was covered on the outside with a sheet of metal. A metallic bar was placed inside the tube, and from it a wire was led to the dark box. On connecting the exterior metal surface with almost any portion of a long battery circuit, which was interrupted, sparks were seen in the dark box at every break. These sparks possess all the properties claimed for the "etheric" sparks. In this case no person at all familiar with electrical induction would for a moment question the true origin of the sparks seen in the dark box.

Metallic coatings are not necessary to produce the effects just described. In the following experiment we replaced them by liquid surfaces: In a tumbler partly filled with slightly acidulated water, a test tube is placed, also filled with acidulated water. The wire *W*, connected with the battery wire *B*, interrupted at *K*, is inserted in the test tube. The wire *S*, in connection with the dark box, dips into the liquid in the tumbler. On interruption of the circuit, sparks appear at the dark box *P*. Comment is unnecessary.

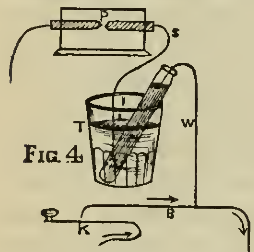


FIG. 4.

It may be interesting to state that the foregoing experiments were thought out in accordance with the known laws of electricity and the results fully confirmed our expectations. It is hoped that the foregoing experiments will have established still more decidedly the fact that *all the manifestations classed as "etheric" are due solely to inverse currents of induced electricity.*

ANTHRACITE METALLURGICAL COKE.*

The desirability of avoiding the introduction of sulphur into the metal at any point of the process of manufacture has led iron and steel makers to give the utmost attention to the selection of fuel, and to make numerous experiments, but it frequently happens that a fuel offering advantages in one direction has more than equivalent disadvantages in another. It may be to this fact that the non-introduction of peat and of anthracite coal as metallurgical fuel may be attributed,

* From the *Mining Journal*, London, March 11, 1876.

for peat is known to possess properties which would lead one to expect a quality of metal equal to the finest brands of Swedish, whilst anthracite possesses a high calorific power and enjoys a freedom from sulphur and ash, which should ensure its general adoption, both in the cupola and in the blast furnace. It has, however, been ascertained that with our present knowledge, peat cannot be successfully and economically employed, whilst with regard to anthracite coal it has the serious objection of readily breaking, both in handling and in heating, into what may almost be described as powder, and which is very difficult to burn, or otherwise deal with in the furnace. In the blast furnace this decrepitation is, as Mr. W. Hackney very truly stated in his paper read at the Manchester meeting of the Iron and Steel Institute, and published in the *Mining Journal*, of October 2, especially injurious, as the fine dust is apt to form together with the cinder pasty masses that can neither be melted nor burned away, and may choke the furnace up or seriously derange its working. These difficulties in the way of using anthracite generally, in its natural or raw state, have led to many attempts to make it into a serviceable coke, by coking it in admixture with a greater or less proportion of binding coal, pitch, or other bituminous substances. None of these attempts until very recently appear, however, to have been commercially successful; none, at least, of those made in South Wales have been carried out largely or continuously, as, though coherent coke was made, it was friable and of inferior quality.

But the great promise which anthracite coke gave of becoming a valuable metallurgical fuel, provided certain comparatively trifling objections could be overcome, was a sufficient inducement for inventors to labor on in the same direction; and at last, by the process of Messrs. Penrose and Richards, of Swansea, a hard and sound anthracite coke was successfully made on a working scale. So great has been the success of the process that the Landore Siemens Steel Company have now 120 ovens making anthracite coke; they use it and nothing else in their blast furnaces, with constantly improving results; they now make a ton of iron with less than a ton of coke. More recently the process has been tested, with highly satisfactory results for the manufacture of the anthracite coke, with the anthracite and anthracite culm, from Mr. F. H. Smith's Rhos Aman Collieries, near Swansea and Llanelly. The resulting coke was tried at the Three Counties Foundry, Cwm Twrch; and, with regard to its

behavior, Mr. John Thomas writes that after lighting and filling up the cupola they charged as follows:

	1.	2.	3.	4.	5.	6.	7.
Pig iron and old railway chairs, cwts.	4	4	4	4	4	4	6=30 cwts.
Coke, . . . lbs.	32	32	32	32	32	32	—=192 lbs.

This completed the iron they had to cast, but if they had had more work to do they might have gone on at the same rate as long as the cupola would last in repair. The iron came out hotter than usual with them, and suitable for the finest castings, although the proportion of coke to the iron was less than half of what they use of the best ordinary coke from Bridgend, and his foreman was of opinion that they might have put in 5 cwts. of iron at a time instead of 4 cwts., with the same result, in which he agrees with him.

The Landore Siemens Steel Company have at the present time two blast furnaces at work, and using anthracite coke exclusively—one on hematite ore, 65 ft. high by 17 ft. "in the bosh"—one on spiegeleisen, 10 ft. lower. As the latter has been only a few days at work the following statistics given relate only to the former: The make of pig iron was 300 tons per week from the one furnace, to produce which nearly 2 tons of 50 per cent. ore, and 18 cwts. of anthracite coke to the ton of pig iron, are used. The same furnace, when using best Glamorgan coke, took 27 cwts. to the ton of iron produced, or 50 per cent. more than anthracite coke, the yield being as nearly as possible the same with both. The quality of the iron is also much the same, but less sulphur with the anthracite. The Landore Company have bituminous collieries of their own, but the quality of the coal not being so good as that from which the best Glamorgan coke is made, they required when using the coke from their own coal 32 cwts. to the ton of iron. With regard to the furnace on spiegeleisen which has, as before mentioned, only just commenced using anthracite coke, it can only be stated at present that they started with $33\frac{1}{4}$ per cent. more burden than they had been putting in Glamorgan coke, the result being perfectly satisfactory, and they have no doubt whatever that in a few days they will increase the burden to the same extent as the other furnace, their only reason for placing less, being the exercise of proper caution in starting. From the foregoing it appears evident that anthracite coke is 50 per cent. more valuable than best Glamorgan, so that if you take the cost of making the former at the outside estimate of 10 per cent. or 15 per cent. more

than the latter, there is plenty of margin. It is stated that some foundries in the neighborhood give the Landore Company 7s. or 8s. per ton more for what they can spare of anthracite coke than the price of best ordinary coke, and are glad to get it.

With regard to the commercial result to be anticipated from the manufacture of anthracite coke it would seem to be encouraging, but this will be more readily judged of by the consideration of the character of the process. Tne materials being thoroughly crushed and mixed in the proper proportions, the coking process is proceeded with. The ovens used are of the oblong shape generally employed in South Wales—15 ft. long, by 5 ft. 7 in. wide at the back, and 6 ft. 2 in. in front, 4 ft. 4 in. high, to the under side of the arch. Each oven is charged through a hole in the roof with about 4 tons of the crushed mixture; this is leveled by a rabble put in through the door at the end, and a small quantity of bituminous coal, sufficient to form a layer about 2 in. thick, is thrown in and spread uniformly over the surface. The oven is then lighted by throwing a few shovelfuls of hot embers on the charge immediately inside the door, and the coking is managed as in working an ordinary charge of bituminous coal. The object of covering the charge with a layer of bituminous coal is to prevent the burning away of the pitch, and its use appears to be essential for the production of a hard and strong coke. Ordinary slack, of the same quality as that in the mixture, is used for the covering; this is mostly very small, but is not especially crushed. Rather more than two charges per week are made in each oven; the coke is watered in the oven, and is then drawn out in one mass by a chain and hand winch. The yield of coke is 80 per cent. of the weight of the charge. The coke is steel gray in color, and very much harder than the anthracite from which it is made; so hard, indeed, that it scratches glass with comparative ease. In a common fire, or under the action of a blast, it burns away without showing any tendency to crumble or decrepitate. It is about 23 per cent. heavier than the best coke made from Welsh bituminous coal, so that in sending a cargo abroad recently a vessel that could not carry more than 240 tons of ordinary coke was able to take in as much as 310 tons of anthracite coke. Another valuable consequence of the dense compact character of the coke, in addition to the saving in cost of carriage, is that even if soaked in water it takes up very little, only from 1·5 to 2 per cent. of its weight, while many kinds of ordinary coke

absorb readily 10 per cent. or more. The saving of labor in charging the furnaces will also be considerable, as there only need be two-thirds by weight of the anthracite coke put into the furnace to do the same amount of smelting as ordinary coke, and the furnaces will yield a much greater quantity of pig iron. The coke is harder and more dense the finer the materials are crushed, and the more intimately they are mixed.

In carrying out the process the anthracite culm, slack, or coal, is disintegrated, and if containing earthy matter, or silica, pyrites, and such like, is well washed; it is then mixed in the proportion of anthracite small 60 per cent., bituminous small 35 per cent., coal tar pitch 5 per cent. = 100. One ton of this when converted into coke will yield 16 cwts. of best coke, or 80 per cent. Its property is that it is very hard, and will carry the iron well in the smelting furnace, saving thereby 27½ per cent., and in the cupola nearly 40 per cent., against ordinary South Wales coke. The cost of machinery and plant for disintegrating, washing, mixing, &c., for 150 tons a day will be about 1500*l.*, exclusive of ovens. A complete plant, including ovens (100) for turning out 100 tons per day, will cost about 8500*l.* The cost of preparation of 80 tons of coke per day will be :

Anthracite culm,	65	tons at	3s.	6d	£11	7	6
Bituminous slack,	35	"	4	6	7	17	6
Coal tar pitch,	5	"	35	0	8	15	0
Cost of disintegrating,	100	"	0	6	2	10	0
Cost of washing,	100	"	0	6	2	10	0
Superintendence, &c.,	100	"	0	6	2	10	0
Labor, including loading and drawing,	100	"	1	0	5	0	0
Total,					£40	10	0

Producing 80 tons of coke, or per ton,	£0	10	2
Interest, wear and tear and repairs of machinery, ovens, etc.,	0	1	6
Royalty to patentee,	0	0	6
Carriage of coke to Swansea, including wagon hire,	0	1	6
Total,	£0	13	8

Many thousands of tons of the anthracite coke have already been made, and it will, probably, be much more extensively made hereafter, for it is considered that the field for the application of any practical method of utilizing small anthracite is very great. The quantity

available in Wales and in America is almost unlimited, and very much of that raised is now unsalable, merely because it is too small to be used. In Pennsylvania, according to Mr. Bell, one-fifth to one-half of the material brought to the surface in the anthracite collieries is thus thrown aside, partly shale and stones, but chiefly small and dust coal, perfectly bright.

ON TURBINE WHEELS.

By Emile Geyelin.

[*Read before the Franklin Institute, March 5th,* 1876.]

The subject to which I would call your attention this evening, is that of *Turbines.*

Before defining the meaning of the word Turbine, allow me to say that "water," the element made use of, having a given weight, $62\frac{1}{2}$ lbs. per cubic foot, becomes a source of power when that weight, owing to the topographical formation of the country, can reach a lower level; and that power, is proportionate to the quantity of water, in a given time, as well as to the height it is allowed to fall—power being the product of weight multiplied by velocity.

The means by which water is made to impart power, are, as you all know, water wheels (and I might add water engines), of which undershot, breast and overshot wheels form one class, and turbines form another; the distinguishing features of these wheels being, that whereas in the first class, the water is allowed to act more by its weight, in the turbine class, it is allowed to act more by the speed due to the fall under which it operates. The term turbine is derived from the Latin "*turbo, turbinis,*" *a whirl or top.* It would imply, and, in fact, I have seen it often stated, that it means water wheels turning on vertical axes; but it is not necessarily so, since they are, especially when brought to use under high falls, coupled together on a horizontal shaft, and in that position produce satisfactory results; in which case, the water being admitted in opposite directions, neutralizing the great pressure that would otherwise be exerted on the step.

A review of the development of the *turbine* is a most interesting one; but we do not find any gigantic strides, such as the introduc-

tion of the railroad and the telegraph has made in the first half of this century. Still we can admire the final results, and see that through the patient labor of years, step by step, man has learned to avail himself of nearly the whole of nature's power in water; and with such certainty, too, that the greatly accumulated force can be relied upon with the same confidence as the daily rising of the sun.

Thousands upon thousands of our fellow beings derive a livelihood through its agency, and its effect upon the wealth of a people can be read in the plainest of language by looking at New England to-day. Holyoke, Lowell, Lawrence, Manchester—those young giants whose wealth is wholly created by water power, as developed by turbines, are but a fraction of what New England has already accumulated from its vast resources. Large amounts lie yet dormant in her streams, to be called into usefulness by her future engineers and capitalists.

Let us now follow the gradual development of the water wheel; at best, we can but slightly touch a subject of which volumes may be profitably written.

FLUTTER AND UNDERSHOT WHEELS.

The most primitive structure, to be found in the backwoods, far from any human centres—the Flutter wheel—seems like the first seed. Water may be plenty, but the means are scant. The noise of the water as it splashes on the rudely shaped buckets, will attract you towards it. Most likely, in a picturesque spot, you will find it, perched on moss-grown rocks, a slender axle holding a frame, to which are secured a few plates. No formulæ laden with Sinus-Cosinus—cube root or other algebra—have given direction to its simple form. Shall we value it less? Let the tourist say, who, in the fragrant atmosphere of its surrounding pine and hemlock, has watched its unskilled efforts to shape a few boards. Near akin to the flutter wheel we have the undershot wheel; more pretentious in its fitting apron, whereby less gamboling of the water is allowed, as it comes dashing along. Look at the straight plates! Note how the water strikes them unprepared, to be left free a few moments later to continue its downward course! Are you surprised when told that one-third of the *vis viva* is all that these wheels develop? At this step science lends its help. First note how it bends the bucket, into flat surfaces at varying obtuse angles; then to the graceful curve of the "Poncelet wheel." Here are no sudden shocks;

the plates quietly receive the pressure, and like a kind friend, hold the water in their folds to the very last. As a consequence, as high as sixty per cent. of force of the water has been developed by these wheels. The undershot wheels are adapted to low falls, and specially where slow motion is required, such as for the purpose of forcing air or water; but even in these conditions the turbines gradually take their places.

OVERSHOT AND BREAST WHEELS.

Many, no doubt, can remember when no other kind of water wheels would have found approval; and this day, for a small varying stream, what can give better returns than the slow, patient overshot wheel, waiting for the water as it comes filling bucket after bucket, and turning round when ready with its well filled side? It is not in this puny capacity, however, that the merits of the overshot or breast wheel should be estimated. Years ago many a stately factory was propelled by them. But valuable as they are in their application to the falls varying from twelve to sixty feet, they have objectionable features which their rival, the turbine, has not; they are therefore fast losing ground.

Let us examine these objections. We have, for instance, the comparatively large size, especially where a large power is required in a concentrated form, such as the propelling of a large cotton or woolen mill. Again, the fact that for the most cases wood is employed in their construction, which renders them short-lived and liable to many stoppages and repairs, we have also the necessity of having them housed in winter to prevent the ice from forming on their buckets; and last, but not least, we have as an objection, the loss of power by friction, created by the changing of their slow motion to the high one of the main shaft, which in most mills amounts to an increase from ten to twenty fold. All these objections are common to both the breast and overshot wheels, but the breast wheel presents comparative advantages over the overshot, which renders the preference for the turbine over the former, less marked.

Take, for instance, a stream wherein the water level varies; the breast wheel, with the arrangement of gate, can adapt itself more readily than the overshot wheel. When the upper level falls say eighteen inches, it draws from the lower gate; whereas the overshot wheel, unless originally constructed with a pressure greater than

necessary in the ordinary stages of the stream, will not be able to receive as much water as needed, owing to the reduced pressure over the gate. Another advantage of the breast wheel is that the water, as it leaves the wheel, is forced away, whereas the water, as it leaves the overshot wheel, is, to some extent, drawn under—thus submerging the buckets to some extent. In the overshot wheel, also, much of the water leaves the wheel before the lower level is reached, and therefore its developed duty is proportionally lessened.

Though overshot and breast wheels are not to receive our special attention on this occasion, I have dwelt somewhat at length on their main features, so as to be better prepared to review the second class of water wheels, namely:

TURBINES.

How long water wheels revolving on vertical axes, or, to speak more properly, water wheels depending more on velocity than on gravity, have been in use, I am unable to say; it is quite certain, however, that fair specimens were left in Spain by the same people who left the Alhambra and other architectural wonders. Coming to more recent times, Belidor, the famous hydraulic engineer, a century and a half ago, in describing the fountains of Marly, amongst other kindred subjects, gives us descriptions and plans of water wheels belonging to this class.

Until the beginning of the present century, the record of advance made in the construction of turbines, is not worth stating; but the earlier years of the nineteenth century exhibit the fruit of patient labor, as shown in the Fourneyron turbine. This turbine was improved, both in detail and in efficiency, by two of New England's honored sons, Uriah H. Boyden and James B. Francis—the former of whom can be considered its introducer into the mills of the United States. The perfection of their work rendered possible the great accumulation of power, whereby so many human hives are enabled to labor with profit to themselves, and to change the rocky hills into green and enlightened homes.

To state that the Fourneyron turbine was the only one of any merit, even a quarter of a century ago, would not be correct, since formidable rivals, especially those offering the advantage of smaller cost, soon made their appearance, and year by year since, these new, or fancied new, applications of the water, turned up; until now, the turbine family is so large that its very names become bewildering.

In a theoretical point of view, matters become much more simple, since many of the turbine wheels known to the public are but combinations, and sometimes simply poor imitations of the parent stock.

For the purpose merely of tracing the analogy of the different kinds of turbines, I should like you to note that in the simplest form, a jet, and in more perfect forms, a series of jets, gradually prepare the water to strike the plates of the revolving wheel. It is in the perfection of the direction of these jets, and the corresponding area of a section of them to the area of the openings for discharge in the revolving wheel, that the main advantage of a turbine lies. The better class of turbines embody the principle of reaction, whereby an additional force is obtained.

The *Scroll*, *Reynolds*, *Trips* and *Parker* wheels illustrate the principle of a single jet. The water is led to the wheel through a contracted channel, and by increased velocity, strikes the plates of the revolving wheel. The Scroll, Reynolds and Trips, by the eccentric form of the casing, are able to act on the greater part of the periphery. The additional velocity to reach the extreme points, created by the contraction of the inlet, must always be obtained at the sacrifice of power; since the maximum effect of the water, can only be obtained when the full pressure due to the fall is brought into action at the first point of contact with the wheel which, must be so constructed and speeded that the water will leave the wheel with the minimum of velocity. The wheels above named, can *not* thus lay claim to high duty; from the simplicity of their construction, and especially where great economy of water is *not* necessary, they are much used. They are the pioneers to prepare the way for a more economical class of wheels to take their places.

Before speaking of the wheels where a series of jets are used in connection with the reaction principle, I would call your attention to the wheel acting *solely on the reaction principle.* In its primitive form it is known as *Barker's* wheel. A hollow, upright tube, through which the water is led to two arms, near the extremities, and on the sides of each arm are openings for the escape of the water; this simple construction comprises all the component parts of a Barker's wheel. A better form of this wheel, made with a closer application of hydraulic laws, becomes the "Scotch motor," in which the water is brought in an ample tube to two gradually diminishing and gracefully curved arms, whereby the water is allowed to retain much of

the pressure due to the difference of level under which it operates, and thus produce results which render it a most desirable motor; particularly where a constant changing of power is desired. The most successful application of that class of motors is at the Morris Canal, where they are used to propel the winding apparatus whereby canal boats are raised and lowered. Their construction is so plain that they proved most durable under quite unfavorable circumstances.

This reaction or retrograde force is thus the *additional* force whereby the highest returns of the water have been obtained. The first one to apply the double sources of power, *impact* and *reaction*, was Fourneyron.

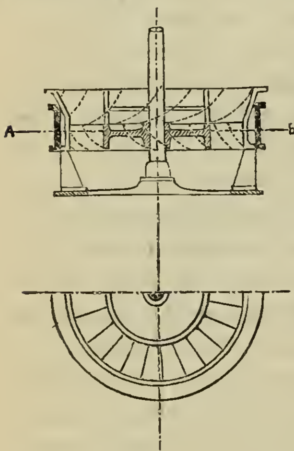


Fig. I.

The turbine represented on the screen (Fig. I) is an exact copy of one built by Fourneyron himself, 40 years ago; were I able to give you on the same screen the same class of turbines as constructed by Boyden & Francis, you could not avoid admiration for the thoroughness of their researches in finding, applying and perfecting of curves, and for the mechanical appliances, whereby the water is divided and prepared, from which curves and appliances were derived those astounding results (92 per cent.) of the total efficiency of the water power; that is of what power it would require to replace the water used in propulsion back again in the basin. Notice the avoidance of sudden change of direction of the water, which, you will observe, is brought in a spacious conduct, whereby no great velocity is created: Standard velocity being from 2 to 3 feet per minute, nearly all is saved for the time of action on the wheel; from the base it is led by well formed cylindrical curves, secured on a stationary disk, to the plates of the movable wheel: The angle at which the water leaves the guide plates is calculated to strike the plates as near the tangent as possible: The angle is in the best wheels from 14° to 15° to the tangent, which becomes the angle on which the force is applied: By a gradual contraction of the space between the plates of the revolving wheel, the water is brought to the point of discharge, which is so arranged as to direct its retrograding force so as to bring the resultant force at a still more

reduced angle to the tangent: Careful computations make the ratio of forces as 8 is to 2.

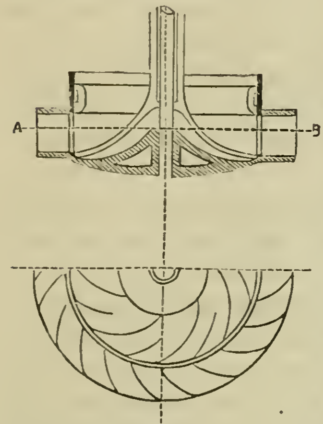


Fig. II.

In the year 1840, Jonval gave a new turbine to the world (Fig. II), which embodied a novel feature, in France at least, where it was invented, namely, the application of the vacuum. But a number of years previous, Zebulon Parker, in the State of Ohio, made practical applications of it in this country; he named it the draft tube. This draft tube is an air tight casing, in which the water discharges after it has left the turbine; its lower extremity is submerged in the tail race water and thus excluding the air. The practical effect is that a turbine provided with this draft tube can be placed between both levels that constitute the fall, and produce the same result as if the turbine were placed at the bottom of the fall. Where it is not desirable to make deep excavations, this application of draft tube becomes valuable. Before going any further, I would state that all downward and inward discharge turbines, invented since, are making use of this feature.

The action of the water is somewhat different in the Jonval from what it is in the Fourneyron. A series of carefully prepared plates prepare the water for action, by directing it from the perpendicular to an angle of 16° with the horizontal surface when it is brought in contact with the plates of the revolving wheel, which plates are so placed as to receive the entering water as favorably as it is received by a Fourneyron wheel, but, instead of the water discharging outward, in the Jonval turbine it discharges downward. As usual with all downward discharge wheels, the *Jonval* has the merit of compactness—and in connection with the fact of being able to place it in any position between the two levels, makes it a very desirable hydraulic motor.

Let us now pass in review the remainder of the turbines most favorably known. 1. The charts represent the Swain, the Liffel, (double), the Risdon, the American, and the Excelsior. All these wheels, either discharging inward or outward, make use of the double action of impact and reaction, and were they all constructed by the same mechanical engineer, very little difference would be found

in the return of power from any given fall and quantity of water. The principal cause of loss of efficiency is to be found in the want of proper mechanical and engineering skill in adapting any particular wheel to the conditions under which it is to work, and specially so is the operation of gate or gates wherewith to open, close or regulate the quantity of water to be used. For the purpose of facilitating the comparison, I have shown the sections of wheels in cross lines, and of the gate in solid blast.

When performing an equal duty with an invariable supply of water, the gate of a turbine is used merely to start and stop. This condition, however, seldom occurs. Either the resistance varies, or the head, or height of column, of the water varies; and there are two modes of overcoming these variations. The first is to have a series of turbines, sometimes of varying power, connected to a general shaft, and thus connect or detach a turbine as wanted. This plan is certainly good, but often for want of space, or with the view to simplicity and compactness, it is desired to obtain the same results with one turbine. The second mode is that of closing or opening the gate or gates, and thus regulate the supply of water to meet the variation of head or the variation of resistance, or the effect of both variations combined. It stands to reason that the turbine which retains the two elements of power in their greatest perfection, is the one that comes nearest to that desideratum of working the best results under the above named variations. The gate of the Fourneyron turbine, you will observe, is a ring closing between the guide and movable wheel. The effect of this gate on the stream of water must be bad, since it brings the water by an abrupt closure or stoppage, into a flat, thin sheet, which, after passing beyond the gate, is left free to enlarge in thickness, on its way to the outer periphery, with not enough pressure left to act upon the wheel. Of course it would be possible for the makers of the Fourneyron turbine to construct the outer, movable wheel in flat divisions, like a series of separate wheels, one upon another (in place of one wheel, as generally made), when each division of the wheel would only receive water as the gate is elevated; but this construction has not heretofore been used by them.

The *Swain turbine* (Fig. III), you will note, has a better gate than the Fourneyron, since it brings the water between flat surfaces in any position it is put, but it is subject to the same objection as the Fourneyron gate, in not proportionally closing the movable wheel.

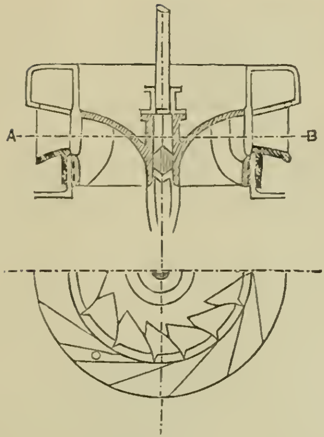


Fig. III.

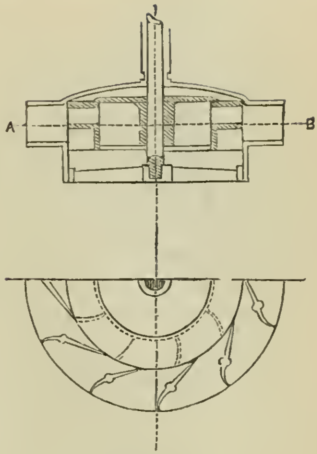


Fig. IV.

The *Liffel* wheel (Fig. IV) presents the same feature as the Swain, of directing the water between the flat, though contracted, passage ways to the point of action, but with it also a corresponding contraction is not established in the movable wheel. The same remarks may be applied to the American turbine (Fig. V), and the Excelsior (Fig. VI).

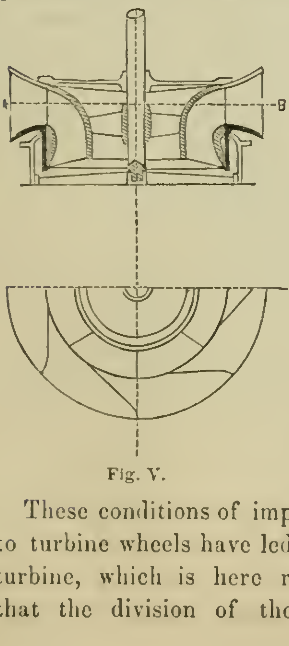


Fig. V.

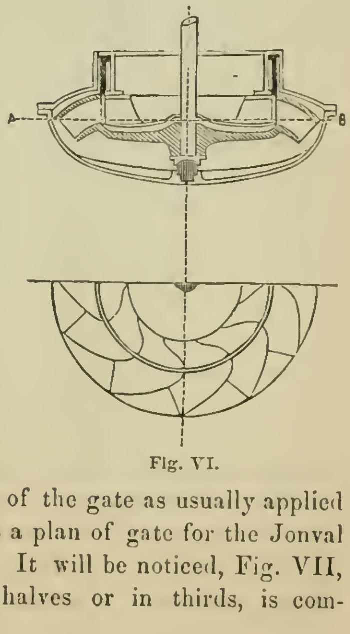


Fig. VI.

These conditions of imperfect action of the gate as usually applied to turbine wheels have led me to adopt a plan of gate for the Jonval turbine, which is here represented. It will be noticed, Fig. VII, that the division of the water, in halves or in thirds, is com-

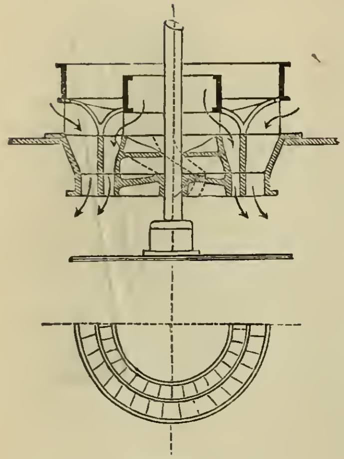


Fig. VII.

plete both in leading plates and in the movable wheel, and the streams do not meet until their duty on the turbine is performed. The water thus gives its proportionate pressure on the wheel as in enters it and as it leaves it. It is hardly necessary to say that careful experiments have proved the advantage of this plan of turbines. The gate of the ordinary Jonval is generally placed at the outlet, where it is free from any injury, and to perform the duty of starting and stopping the wheel, no simpler and stronger arrangement could be desired, but for variable power or variable quantities of the water, the plan was a most unsuitable one, as it removed the point of contraction from the wheel altogether, and merely made a resistance to the flow of water beyond it.

I will close my remarks on turbines by alluding to one of the most interesting features of these water wheels—it is their practical application to any height of fall. I have seen the famous turbine of St. Blasien, made by Fourneyron, operating under 350 English feet fall, giving 73 horse power, which is so well known to readers on this subject of turbines; but as a parallel ~~example to this one, I desire to record one made by me, in 1854, for~~ Saltillo, Mexico, which was a double turbine (that is a turbine receiving water *between* two movable wheels on the same shaft, which counterbalanced each other, and avoided the necessity of resisting the thrust from the head of water) for 160 feet fall, producing 125 horse power, and turning at a speed of 1850 revolutions per hour. This double turbine, though only 11 inches in diameter, propels a cotton mill of 10,000 spindles. and

And now, gentlemen, to show what importance is attached ~~in the~~ practical applications of turbines, I have to say that the U. S. Centennial Exhibition has been engaged in preparing a most complete testing apparatus, where the world at large is invited to bring their wheels to be tested by a competent committee of mechanics. Let us hope that the results will establish the superiority of the turbines of the United States, in the ensuing competition.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LXXI. MAY, 1876. No. 5.

EDITORIAL.

Notice.—The publication of the Journal is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Franklin Institute.

Hall of the Institute, April 19, 1876.

The stated meeting was called to order at 8 o'clock, P. M., the Vice-President, Chas. S. Close, in the chair.

There were present 188 members and 18 visitors.

The minutes of the last stated meeting were read and approved.

The minutes of the Board of Managers were presented, showing that at their last meeting, seven persons were elected members of the Institute, and the following donations were made to the library:

Results of an Experimental Inquiry into the relative properties of wrought iron plates, manufactured at Essen, Rhenish Russia, and

Yorkshire, England. By David Kirkaldy. London, 1876. From the Author.

Historical sketch of Union College [now a branch of Union University], founded at Schenectady, N.Y., February 25th, 1795. Washington, 1876. From the Dept. of Interior.

Annual report of the Chief Signal Officer, to the Secretary of War, for the year 1875. Washington, 1875. From A. J. Meyer, Brig. Gen. and C.S.O., U.S.A.

Bi-metallic money, and its bearings on the monetary crises in Germany, France, England, and the United States; by Henry Cernuschi. Translated from the French. Second edition, London, 1876.

La Monnaie Bimetallique par Henri Cernuschi. Paris, 1876. From the Author.

Report on Vienna Bread, by E. N. Horsford, of the U. S. Scientific Commission to the International Exhibition, Vienna, 1873. Washington, 1875. From the Author.

Circulars of Information of the Bureau of Education; Nos. 1–8, 1875. Washington, 1875. From the Bureau of Education.

Specifications and Drawings of Patents. U. S. Patent Office, October, 1875. From Commissioner of Patents.

British Patent specifications issued November 20th, 1875, to February 12th, 1876.

Commissioner of Patents Journal, from No. 2282, November 16th, 1875, to No. 2307, February 11th, 1876.

Chronological and Descriptive Index, from No. 20, May 6th, 1875, to No. 32, August 4th, 1875.

Abridgments relating to Production and Application of Gas (excepting gas engines). Part II, 1859–66. London, 1875. And Preparation of India Rubber and Gutta Percha, 1791–1866. London, 1875.

Index to Foreign Scientific Periodicals contained in Patent Office Library, Vol. 7, 1872. London, 1876.

Index to Commissioner of Patents Journal, for 1875. London, 1876.

Three Drawings to be inserted in Specification No. 1801 of 1875. From Commissioner of Patents, London.

Court of Common Pleas No. 3, of Philadelphia Co., in equity. The Children's Hospital, *et al.*, vs. Henry Bumm, *et al.* Complainants' Affidavits on motion for Injunction to restrain continuance of Gas Nuisance. From Robert Briggs.

Dept. of the Interior. Bulletin of the United States Geological and Geographical Survey of the Territories, Vol. II, Nos. 1 and 2. Washington, March 21st, and April 1st, 1876. From the Dept.

The following proceedings had at the last stated meeting of the Board, were also reported:

"*Resolved*, That the President is hereby authorized and requested to appoint twenty-six members of the Institute, to be entitled a Reception Committee, whose duty it shall be to take charge of the reception room and attendant in Machinery Hall, and be so subdivided that at least one of its members shall be in daily attendance at the reception room, to receive visitors, and give them such information as they may desire."

"*Resolved*, That the printed notices of monthly meetings of the Institute be discontinued, and that the meetings be advertised by the committee on meetings."

The Secretary reported that at the meeting of the Committee on Sciences and the Arts, held on the 5th instant, the award of the Scott Legacy Medal and Premium, was recommended to Morris L. Orum for his Flexible Mandril for bending metal pipes.

The special committee on the Metric System of Weights and Measures, presented a report signed by Messrs. Coleman Sellers and W. P. Tatham, which was read by the Secretary.

Mr. Robert Briggs from the same committee presented a Minority Report, and proceeded with the reading, but before its completion it was

"*Resolved*, That the further consideration of the subject be postponed to the next stated meeting."

Owing to the lateness of the hour, and with the consent of the author, the reading of H. Bilgram's paper on the "Temperature of the Sun," was fixed for next meeting.

The Secretary then presented his report embracing Clark's Combination Lock; Bilgram's Valve Gear for variable expansion; Houghton's Automatic House Pump, illustrated by a working glass model; and Chambers' Archimedean Brick Making Machine was illustrated by a working model of one-fourth size, driven by a steam engine on the stage, and described by Mr. Cyrus Chambers, Jr., the inventor.

On motion, the meeting went into the election of a Vice-President, and the chair appointed Messrs. J. W. Nystrom, C. Chabot, and Hector Orr, as tellers.

The chair announced that Messrs. H. G. Morris and C. M. Cresson were placed in nomination at the last meeting, and that further nominations were in order.

Messrs. T. Morris Perot, Henry Cartwright, and W. P. Tatham were nominated, but the last two declined.

On motion, a recess of five minutes was taken, for the purpose of preparing the ballots.

After the votes had been taken, the tellers reported that 88 ballots had been cast, of which H. G. Morris received the majority, whereupon the chair declared Mr. H. G. Morris elected to fill the vacancy caused by the resignation of Mr. B. H. Moore.

On motion, a committee, consisting of Messrs. Coleman Sellers, W. P. Tatham, and Henry Cartwright, was appointed to present the names of suitable persons to be elected Honorary and Corresponding members.

On motion of Mr. Briggs, the Committee on Publication was requested to publish the majority and the minority reports on the metric system of weights and measures.

The Secretary read the following names of members appointed to the various standing committees of the Institute:

On Library.—Chas. Bullock, Saml. Sartain, W. P. Tatham, Jos. M. Wilson, Pliny E. Chase, Robert Briggs, J. B. Knight, B. H. Moore, J. W. Nystrom, Dr. Isaac Norris, Jr.

On Minerals.—Dr. F. A. Genth, Theo. D. Rand, Clarence Bement, Persifor Frazer, Jr., Dr. W. H. Wahl, E. J. Houston, Otto Luthy, Robert Grimshaw, E. F. Moody, Dr. Geo. A. Kœnig.

On Meteorology.—Pliny E. Chase, Hector Orr, Dr. Isaac Norris, Jr., John Wise, J. E Mitchell, Jas. A. Kirkpatrick, David Brooks, Alex. Purves, Dr. W. H. Wahl.

On Models.—H. L. Butler, Edward Brown, M. L. Orum, J. Gœhring, L. L. Cheney, A B. Bary, C. Chabot, J. B. Knight, S. Lloyd Wiegand, H. R. Heyl.

On Arts and Manufactures.—A. B. Bary, Geo V. Cresson, Hector Orr, Coleman Sellers, Jr., W. B. LeVan, Wm. Helme, H. W. Bartol, J S. Bancroft, Alfred Mellor, Cyrus Chambers, Jr.

On Meetings.—H. Cartwright, B. H. Moore, Saml. Sartain, Washington Jones, J. B. Knight, C. S. Close, P. E. Chase, W. P. Tatham, J. S. Bancroft.

Mr. Orr presented the following, which was adopted:

Whereas, the present signal service has most emphatically vindicated the anticipations of scientists, in furnishing valuable practical information to important interests, both on sea and land. Therefore,

Resolved, That we cordially commend the establishment of said service on a permanent basis, under ample provisions for its general introduction throughout our coasts, as well as inland, and respectfully invite the action of Congress on this subject.

On motion, the meeting then adjourned.

J. B. Knight, *Secretary.*

ELECTRICITY VS. GAS.*

The Great Northern Railway Company of France has undertaken a series of experiments which seem to indicate the approach of a great revolution in the mode of lighting public buildings and thoroughfares. To judge from the reports recently published, electricity seems destined to eclipse gas altogether. A few weeks ago a three-horse power Gamme machine was employed to light the luggage department of the Paris Great Northern Railway station. This room or hall measures 20,000 cubic feet, and is generally illuminated by twenty-five gas-burners. The new electric light was placed at a distance of 10 metres from the ground, and gave a light of a peculiarly soft character, which rendered the use of the dull globe employed to check the irritating glare of gas quite unnecessary, — a fact of some importance, as it tends to augment the economy realized by the new system. The light continued to burn the whole evening with great regularity, excepting, of course, when it was purposely lowered. The success attained was so conclusive, if we may believe accounts, that the company intend illuminating the vast structure, containing 300,000 cubic metres of space, where the trains arrive, by the same process. For this purpose electric lanterns, if we may so call them, of exceptional power, will be placed at a height of 20 metres. They will be placed at the four summits of a rectangle, so there will be no shade or dark corner in the whole edifice. The goods station at La Chapelle will also be lighted in a similar manner.

M. Tresca, an energetic advocate of the electric system, has been able at last to estimate the amount of power required to produce a given quantity of light by the magneto-electric machines. In this respect former experiments had been eminently unsatisfactory, and M. Tresca gives an exhaustive description of all the difficulties that had to be surmounted, in a report which is inserted in the minutes of the Academy of Science. The results have been obtained chiefly from two machines; the first giving a light equivalent to 1,850 carcel-burners, that consume forty grammes of oil per hour, and the second equal to 302 similar burners. With the former it is easy to read at a distance of 21·50 m., and with the latter at 7·70 m. The reflection, also, from the walls is so strong that persons can read at these dis-

* From the *Builder*, April 1st, 1876.

tances even when holding the book with its back to the light. From a lamp equal to a hundred burners the same result can be obtained at a distance of five metres. Four electric lamps of this power have been use during the last year in the factory of Messrs. Heilmann, Ducommun, & Steinlen, of Mulhouse, and give a satisfactory light over an area of 1,850 square metres. The most important and crowning fact, however, is the assertion that the electric light is a hundred times less expensive than oil, and fifty times cheaper than gas. Should a prolonged and practical application of the new system prove this startling comparison to be correct, we may look forward to a great change, which will ultimately compel the gas-makers to, at any rate, make a great alteration in their scale of charges, if it should not interfere even more seriously with their interests.

New Bridges—Approaches to the Centennial Grounds.— In order to complete the approaches to the Centennial Grounds, three bridges over the tracks of the Pennsylvania Railroad are now being constructed, and will all be finished shortly. They are located at Fortieth and Forty-first streets, and at the intersection of Belmont and Girard avenues, and are built by the Pennsylvania Railroad Company, which shares the expense with the city. The bridge at Fortieth street is estimated to cost $87,068; that at Forty-first street, $67,980, and that at the intersection of Belmont and Girard avenues, $300,000.

The bridge at Fortieth street is of wrought iron, and is built on the principle of the "Ordish Rigid Suspension Bridge." It consists of three spans—a centre span of 171 feet 11$\frac{5}{8}$ inches, and two side spans of 74 feet 11 9-16 inches, making a total clear span from abutment to abutment of 321 feet 10$\frac{3}{4}$ inches, and will give room on the railroad beneath for 22 tracks. It is placed at such an elevation as to give a clear height below of 17$\frac{1}{2}$ feet above the Pennsylvania Railroad tracks. It is 60 feet wide, with outside walks 10 feet wide on each side, leaving a roadway of 40 feet. The towers are four in number, situated at either end of the centre span, and are 60 feet high, surmounted by ornamental iron spires, topped of with wrought iron vanes. They are of wrought iron, resting on stone foundation piers. The main cables rest on the towers, 42 feet above the floor.

The peculiarity of this style of bridge is that the cable rests on the tower exactly at the centre of its length, and is attached to the bridge at each of its ends, thus making the weight of the bridge balance on the tops of the towers, and avoiding the necessity of anchoring the ends of the cables. The suspension cables are of wrought iron links, with pin connections. The lower chord is of boiler plate, and wrought iron cross girders are placed at every eight feet, supporting timber floor joists, which run lengthwise of the bridge. The roadway and footways are covered with a sub-flooring of white pine, and above this, on the roadway, a flooring of three-inch white oak. On the footways is a second flooring of yellow pine. The bridge is strong enough to bear a load of 4,800 pounds to the linear foot. The bridge is very handsome in appearance, having footways of tasteful design. The towers are also elaborately ornamented. The bridge is finished.

The Forty-first street bridge is on the stiffened triangular truss system, and is not so ornate in appearance as the Fortieth street bridge. It consists of one span, 209 feet 3 inches long in the clear, and is placed at such an elevation as to give a clear height below of 17½ feet above the railroad. The bridge is 60 feet in width, having two trusses with outside sidewalks. The material of the trusses is wrought iron, and wrought iron girders are suspended from the trusses about every 10½ feet. These support timber floor joists. The flooring is similar to that of the Fortieth street bridge, and the structure will bear about the same weight.

The bridge at the intersection of Belmont and Girard avenues is an iron truss structure, and is crossed at right angles by Belmont and Girard avenues. It is 360 feet wide on the southwest side and 240 feet wide on the northeast side. It is 300 feet long in the centre of Girard avenue and 150 feet in the centre of Belmont avenue, leaving room on the Pennsylvania Railroad for ten tracks. There is already a good iron bridge carrying Belmont avenue over the track, and this bridge has been widened 100 feet. Another bridge of the same width has been constructed at Girard avenue. The bridges thus run together, making one complete structure, resting upon the same abutments, in the form of an irregular cross. It is one of the largest street bridges in the country.—From the *Public Ledger*, Philadelphia, April 26th, 1876.

Bibliographical Notice.

A PRACTICAL TREATISE ON ROADS, STREETS, AND PAVEMENTS.—By Q. A. Gillmore, A.M., Lieut. Col. U.S. Corps of Engineers, Brevt. Major General U. S. Army. New York, D. Van Nostrand.

Some years ago, a work was published by Gen. Gillmore on Limes, Cements, and Mortars, it being No. 9 of a series of papers on Practical Engineering for the United States Engineer Department. It contained a large amount of valuable information on the subjects treated, became in fact, the standard authority on those questions in this country, and has already reached its fifth edition.

Some years later, another work appeared by the same author, on Coignet Beton, full of practical and detailed information concerning the different kinds of artificial stone employed to so great an extent in Europe, and the use of which is every day increasing in this country.

To day, we have before us another one of these practical works, "Gillmore on Roads," being a treatise on the construction of roads, streets, and pavements. The author states that in preparing the work, he has endeavored "to give within the compass of one small volume, such descriptions of the various methods of locating country roads, and of constructing the road and street coverings in more or less common use at the present day, as will render the essential details of these methods, as well as certain improvements thereon, of which many of them are believed to be susceptible, familiar to any intelligent, non-professional reader." "To make such practical suggestions with respect to the selection and application of material, more especially those with the properties and uses of which builders are presumed to be the least acquainted, as seem needful in order to develop their greatest practical worth, and realize their greatest endurance." "Also to institute a just and discriminating comparison of the respective merits of the several street pavements now competing for popular recognition and favor, under the varying conditions of traffic, climate, and locality, to which they are commonly subjected."

The objects at which the author aimed, seem to have been fully and ably carried out, and in a language and style that one may study with both profit and pleasure. The work commends itself to the general reader as well as to the engineering student, and information such as here given, is just what is required by those who have charge of the repairs of our country roads. If the directions here given were carried out, it would result in a very different condition of roads from what exists throughout a large portion of the United States at the present time.

Chapters first and second treat of country roads, their location, grades and modes of construction. The important question of grades is taken up in considerable detail; and under the head of construction, the matter of drainage, so often neglected, and on which the good condition of a road so much depends, is given its full share of attention. Chapter third considers the different kinds of road coverings, such as earth, corduroy, plank, gravel, stone, etc. Chapter fourth takes up the question of maintenance and repairs of roads, and chapter fifth and sixth are on streets and street pavements, sidewalks and foot-paths. These last chapters are full of interest and the information is entirely new, giving descriptions and details of the different street coverings now claiming so much attention in our large cities, and about which there are so many conflicting opinions.

In a word we can cordially recommend all those who are in any way interested in matters pertaining to roads to consult this work.

J. M. W.

Civil and Mechanical Engineering.

GAS WORKS ENGINEERING.

By Robert Briggs, C. E.

The following description of the manufacture of coal gas was prepared for testimony in a recent action in equity, for discontinuance of a nuisance incident to some processes in use at the Gas Works in Philadelphia, and as it involves a brief but complete statement of the chemistry, apparatus and methods of gas making, it may prove acceptable information to some readers.

"The making of coal gas by distillation in retorts would be one of the simplest of the manufacturing operations if it were not accompanied with certain other products and involved with certain impurities which it becomes necessary to treat, or to remove, to render the process or its result tolerable to any community. To make the whole of this process intelligible, I will state, as a brief of the operation:—

"§ I. Coal oil, for illuminating purposes, is produced from bituminous coal by destructive distillation. [Ordinary distillation, as of

alcohol from wine, merely separates by evaporation at a lower temperature, one substance from another; *destructive* distillation alters chemically, by heat, the nature of the bodies exposed to the operation.] Bituminous coal itself is assumed to be a fossil of vegetable origin, which may have been charred by heat and solidified by pressure; and it consists of the following elementary substances:—first, and mainly, carbon; second, sulphur; third, silicium (with very small quantities of other earth metals); fourth, iron (rarely any other metals); fifth, hydrogen; sixth, oxygen; seventh, nitrogen (with very small proportions of other gaseous bodies). One ton (2240 pounds) of bituminous coal, of average quality, will produce about nine thousand to ten thousand cubic feet of gas, also of average quality. Gas of average quality is held to be such, that the burning, in a suitable burner, at the rate of five cubic feet per hour, will evolve an intensity of light equalling that which will proceed from fourteen to sixteen *standard* sperm candles, of six to the pound, each burning 120 grains per hour. This ton of coal will also yield, and pass off from the retorts *with the gas*, as vapor, about twelve to thirteen gallons of coal tar, and fifteen to seventeen gallons of ammoniacal liquor; and after the volatile portions have passed away from the retort almost completely, (that is, when the gas from the retorts ceases to possess the requisite illuminating power), there remains in the retorts about 1700 pounds of spent coal, denominated gas coke.

"The four products of coal, which are separated distinctly in the process of distillation, are (stating them in reverse order):—First, coke; second, coal tar; third, ammoniacal liquor; fourth, crude gas. And each of these four products are treated severally.

"[§ § *One.*] The coke which remains in the retorts, and is removed from them at a higher heat, consists principally of carbon (90 to 95 per cent.), while the remainder is the earth metals, and iron and oxygen, together with a little sulphur, perhaps, in combination with the iron. In quenching the coke, a copious steam is produced, which takes off and disperses within a few feet, not generally over 200 feet distant, a quantity of dust of the coke, in the form of coarse, perceptible grains, and a small quantity of sulphurous gas, with a smaller quantity of sulphuretted hydrogen, is dispersed in the atmosphere at the same time. The coke itself, after being cooled, takes up and absorbs most hydro-carbon vapors, carbonic acid and other gases, with much avidity. But little nuisance arises from coke, ex-

cept when the steam and gas of quenching are dispersed at improper elevation, or too near to other property or to public thoroughfares.

"[§ § *Two.*] The coal tar which passes away from the retorts with other volatile bodies, is intimately mixed with them at the temperature at which they leave the retorts, but is mainly condensed in a pipe or closed vessel, denominated the hydraulic main ; some of it, however, passes beyond the hydraulic main and is separated with much difficulty, in the condenser and washers (whose purpose is mainly to remove ammoniacal liquors). Small quantities of coal tar are always found in the pipes in the streets, and if the parts of the apparatus are not properly arranged, the coal tar will be found in quantity in the purifiers, in the street pipes, and even in the house services. This coal tar consists almost entirely of an innumerable and a variable number of definite chemical compounds of carbon and hydrogen, together with those of carbon, hydrogen and oxygen. All these hydro-carbons intermingle with each other in all proportions, making inseparable mixtures at ordinary temperatures ; and they also absorb the gaseous hydro-carbons with which they may be brought in contact, with rates which increase as the temperatures are reduced. A very small proportion of sulphur will be found in coal tar, being probably only that due to the absorption of sulphur-gaseous bodies in the crude gas. Crude coal tar, as it is collected from all sources about the gas works, is a thin liquid at the general temperature of the atmosphere, having at the first moment of smelling of fresh coal tar, a pungent but not highly offensive odor ; but the continued exposure of a considerable surface for evaporation to the air, or the presence of the least of the substance in dwellings or occupied rooms or upon clothing, develops a persistent and disagreeable smell, scarcely equaled by that from any other material in the arts.

"It is admitted by all physicians and chemists that the odors from coal tar vapors are (in the proportion in which they will diffuse in the air) not absolutely deleterious or poisonous, (many of them being classed and used as disinfectants) ; but on the other hand the gas-maker has fully recognized their *objectionable* character ; and in all works, the coal tar is collected in sealed vessels, conveyed about the works in closed pipes, and deposited in a closed tank or cistern, to be afterwards disposed of. The numerous substances mixed in coal tar

separate, by distillation at temperatures below the destructive one, into three classes, 1, light oils; 2, dead oils; 3, pitch.

"On boiling coal tar in a closed kettle up to about four hundred degrees, a mixture of various hydro-carbons will pass off like oils; these can be condensed by a coil of pipe in water, and will be found to be lighter than water; at higher temperatures, up to five hundred and fifty degrees, oils will distill over, which will be heavier than water, and are therefore called dead; after this process, there is left a pitch of numerous bituminous bodies not separated by chemists.

"The pitch is used for roofing, sidewalks, and similar purposes; the oils are sold to make lamp black and for the preparation of printers' ink. But the demand for coal tar or coal-tar products is small, and the price of the latter unremunerative, except to those who can use the products directly, and in some works the coal tar is burned under the retorts, while in many it is surreptitiously wasted or discharged into sewers or streams.

"The light oils will be found to have in them, when condensed, most of the gases that may have been absorbed by the crude coal tar, and their rectification for lubricating oils is first accompanied by the escape of these gases, and after this is done the thin oil becomes not very unpleasantly odoriferous. The gases from this process should be burned, but their extreme levity will always occasion a rapid dissipation in the atmosphere. The heavy oils are less offensive; and the pitch has a characteristic odor not very permeating, or unpleasant to most persons when smelled in the open air, or outside of dwelling rooms.

"[§ § *Three.*] The ammoniacal liquor, like the coal tar, is intimately mixed with the crude gas. A portion is condensed with the tar, but it mostly goes beyond the *hydraulic main* to the condenser, which is a large extent of pipe or plate surface exposed to the air or to water on the outside of pipes or boxes, and acting by cooling the hot gas; when the ammoniacal liquor in the gas condenses and runs down upon the inside, collecting and absorbing ammonia vapor, as the cooling proceeds. After passing the condenser, the gas flows through a washer, where, having become cool, it is brought in contact with streams of ammoniacal liquor or fresh water, which take up and remove nearly all the ammonium compounds; water having a very high absorption rate for them when cold, and parting with them readily when warm.

"The ammoniacal liquor consists of water holding in solution various compounds of ammonium, (NH_4) with carbon, sulphur and cyanogen (CN). The liquor also has absorbed definite quantities of sulphuretted hydrogen and of all other gases present. This ammoniacal liquor is exceedingly offensive and permeating. The hair and woolen clothes absorb the ammonium compounds with much avidity, and retain the odor for a great length of time. The objectionable nature of these odors is admitted by all, and every means is taken, in gas works, to isolate and remove the ammoniacal liquor. Until recently (in this country) it was discharged into sewers and streams, where it aggravated inconceivably the condition of the sewage water and poisoned the stream; but in all well managed works of to-day, the ammoniacal liquor is treated (or removed in pipes to other places for treatment) so as to yield a good return to the maker and avoid all nuisance; as the treatment can be carried on without the least exposure of the liquor to the air.

"[§ § *Four.*] The crude gas, being freed from tar and ammoniacal liquor, is yet charged with certain impurities which should be removed before it can be distributed in the mains and burned in stores or dwellings. It consists of four parts: *a*, the burning substances; *b*, the luminous or incandescent ones; *c*, the impurities; *d*, certain non-burning substances. (*a.*) The burning substances are hydrogen; one of the compounds of hydrogen and carbon (marsh gas, CH_4); and carbonic oxide, or half-burned carbon. (*b.*) The luminous or incandescent substances are numerous carbon compounds which may be substituted for each other, in any separate examples taken for analysis, but which do not exceed four per cent. of the gas for fourteen-candle illuminating power. (*c.*) The impurities to contend with are sulphuretted hydrogen, sulphur and ammonium components, and naphthaline. (*d.*) The non-burning substances are atmospheric air and carbonic acid.

"The sulphur-compound impurities are the most objectionable to the consumer, as the immediate result from imperfect purification in this regard is a complaint by them. The legal requirement, in England, is that the gas shall be purified from sulphur compounds, until it will pass inspection at less than twenty grains weight of sulphur to one hundred cubic feet.

(To be continued.)

THE EFFICIENCY OF ROLL TRAINS.

By Wm. Hewitt, M.E.

General Remarks.—The efficiency of any machine is the fraction of the whole amount of power communicated to it, which may be usefully developed, or the ratio of the useful work executed to the total work performed. When the efficiency is unity, the machine is perfect; that is, it is capable of transmitting the whole amount of power communicated to it. No machine can be perfect, because it is impossible to construct one that will be entirely free from friction. In every machine, more or less power is always absorbed in overcoming this element. The fewer the parts, the less the amount of friction, and, therefore, assuming all other things to be equal, the simpler the machine, the greater its efficiency; hence also the common adage, "simplicity is perfection." But simplicity alone is not sufficient for a large efficiency. Unless the machine is constructed upon correct principles, its simplicity is of no avail. The rectitude of such principles consists in their strict accordance with all the laws of nature. It is useless and foolish to contend against these laws, for, unlike those of our legislative bodies, they will inevitably be enforced. We cannot but pity those unfortunate persons, who, in ignorance of nature's laws, are struggling blindly against them, mistaking their pertinacity for genius, and flattering themselves that they are inventors. And equally must we pity those, who, in search of the so-called perpetual motion, are wasting their time and energy in a hopeless cause, deceiving themselves with the idea that they can create power. He who would devise a machine should understand that a machine should be constructed with regard to obtaining as large an efficiency as possible, and not merely a piece of mechanism. He should, therefore, be instructed in the principles which govern the efficiency of machines, and consequently be intimately acquainted with the laws of nature, for the more strictly he adheres to these, the more completely will he gain the merit of simplicity.

The Rolls.—The determination of the efficiency of roll trains involves the determination of the normal pressure exerted upon the rolls by the hot bar or plate while under compression. The brasses

act as brakes on the journals of the rolls, and if the normal pressure be denoted by P, and the coefficient of friction by f, the resistance will be given by the equation,

(1.) $$R=\frac{P}{f}.$$

The value of P, for each passage of the iron between the rolls, depends upon the amount of reduction produced in the sectional area of the bar or plate. We should seek to make the resistance of the train as nearly uniform as possible, and in order that this may be effected, it is evident that the rate of reduction must be varied according to some function of the variation of the temperature, and the position of the metal in the train. The resistance which iron at different temperatures offers to compression has never been accurately determined; but the diminution of the tensile strength of wrought iron, below the maximum for high degrees of heat, was determined by a committee appointed by the Franklin Institute to investigate the principles relating to the strength of materials for boiler construction, and found to be given by the empirical formula,

(2.) $$D=C(\theta-80)^{2.6},$$

in which D is the diminution after it has passed the maximum, θ, the temperature, Fah., and C, a constant. This formula is sufficiently exact for all temperatures between 520° and 13·7° (JOUR. FRANKLIN INSTITUTE, Vol. 20, 1837). The resistance of iron to compression is about equal to its tensile resistance, and the above formula, therefore, may be applied to the case under consideration, with approximately correct results being obtained.

In using this formula, let R' denote the amount of reduction in the first pass, found by experiment to be most advantageous for the temperature of the pile, a_1, the increase of resistance from the first to the second pass, a_2, the increase from the second to the third, etc. The successive reductions then become, R' for the first pass, a_1R' for the second, a_1a_2R' for the third, and $a_1a_2 \ldots a_nR'$ for the nth pass.

The temperature of the iron, however, is a very difficult thing to obtain accurately, and the method usually employed, is to adopt a rate of reduction which is most favorable to the mean temperature of the iron and the size of the rolls; to calculate the number of passes on the assumption that this rate is constant, and then to depart from this in the various grooves, as may seem most discreet. This requires

considerable experience, especially in rolling wire rods, where the cooling is very rapid. In rolling rails, beams, and plates, however, the problem is not such a delicate one, as the iron cools more slowly.

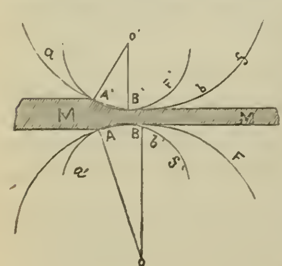
The most rapid and convenient method of calculating the areas of the various grooves is by the use of logarithms. Thus, let the number of grooves be denoted by n, the rate of reduction (assuming it to be constant) by r, and the area of the last groove by a. Then,

Log. of area of pass $n = \log. a$.

" " " $(n-1) = \log. a + \log r$.

" " " $(n-2) = \log. a + 2 \log. r$, etc.

The rate of reduction also depends upon the character of the iron, the dimensions and compositions of the pile, the alterations which the iron experiences in its shape, and the size and velocity of the rolls. We naturally seek to make the rate of reduction as great as possible, in order to accelerate the rolling and not to employ a greater number of passes than is actually necessary, but in order to work smoothly, and manufacture bars free from seams and fins, the rate of reduction and number of passes must be varied accordingly. [Note. A common rate of reduction in rolling rails and beams is 1·3 : 1. In rolling band iron it is often 2 : 1.] Not only should the iron be entered in each pass without difficulty, and the pressure such that the iron will not squeeze out at the open or loose parts of the groove, but neither should the pressure be so light as not to cause the iron to fill the groove. The rate of reduction may be greater, as the velocity and resistance of the rolls are greater, as the iron is stronger, hotter, more easily worked, and as its geometrical shape experiences less changes in the passage from one groove to the next. It is impossible, therefore, to determine the most favorable rate of reduction according to any one precise and invariable rule.



Let ABF, abf, represent a pair of 16 inch rolls, with the metal, MM, between them, and $A'B'F'$, $a'b'f'$, a pair of 8 inch rolls, and let θ denote the angle AOB, which subtends the arc of contact AB.

The amount of reduction being the same, it is obvious that rolls of small diameter have a greater tendency to elongate the metal than those of larger diameter, the

latter spreading it more, so that a bar which exactly fills a groove in a pair of 8 inch rolls, will over-fill a groove of the same size in a pair of 16 inch rolls.

The relation between the velocities of the metal on either side of the rolls, and the velocity of the rolls, has never been investigated that we are aware of. We know that the metal issues with a velocity greater than that of the circumference of the rolls, and we are inclined to believe that the velocity of the circumference of the rolls is a mean between the velocities of the metal on each side. The fact that the metal is never found "banked up" at the points A and A' has led some to infer that the metal must enter with the velocity of the circumference of the rolls, but we hardly think the inference is correct, because we do not believe that the friction between the metal and the rolls is ever sufficiently great to overcome the cohesion of the molecules of the metal, so that instead of the metal being squeezed out at the centre more than at the surface, we believe that it is squeezed out equally and bodily in both directions, and yet carried forward through the groove at the same time. Although the question may perhaps be of no practical importance, it is a curious one and we would like to see it satisfactorily explained. Whatever the truth is, it is evident that there must be a slight slip somewhere between the metal and the rolls, but precisely where that slip takes place we are unable to say.

The Gearing.—The amount of gearing employed in driving roll trains has of late years been reduced to a minimum by the introduction of independent and direct acting engines. Formerly, when the slow moving, low pressure, condensing engine was the standard engine for driving rolling mills, a large amount of gearing was necessary in order to obtain the requisite speed in the rolls; but the quick moving, high pressure, cut off engine, has superseded almost entirely the old condensing engine, so that we are now enabled to drive roll trains directly at the speed required.

Let n be the number of teeth on each pinion, and f' the coefficient of friction. The counter efficiency of each gear in the pinions then will be given by the formula (Rankine's Millwork and Machinery, page 439),

(3.) $$c = 1 + 2\pi\frac{f'}{n}.$$

Notation and General Formulæ.—We will now proceed to investigate the principles which determine the efficiency of the three most important mills of the present day; the "three high" mill, the clutch reversing mill, and Mr. Ramsbottom's reversing mill; assuming that there are in each case two sets of rolls, the "roughing" and "finishing," and that the engine is attached directly to the train in the first and last mentioned mills.

The efficiency of the mill will depend upon its construction, and and will vary with the position of the metal in the train, so that it must be calculated for each pass separately. In the formulæ which we are about to give we shall adopt the following notation:

P = Pressure due to the amount of reduction of the metal.

p = Pressure due to the weight of the metal.

W_1 = Weight of bottom roughing roll.

W_2 = Weight of middle roughing roll.

W_3 = Weight of top roughing roll.

W_4 = Weight of bottom finishing roll.

W_5 = Weight of middle finishing roll.

W_6 = Weight of top finishing roll.

W = Total weight of all the rolls.

W' = Weight of a single pinion.

L = Total length of all the rolls.

l = Length of a single pinion.

T = Time of pass.

t = Time occupied in the performance of useful work.

a = Angular velocity of the rolls.

R = Radius of circle whose area is the mean sectional area of the rolls and pinions.

(4.) r = Mean radius of gyration of the train $= \frac{1}{2} R\sqrt{2}$.

f = Coefficient of friction (between cast iron and brass).

g = Force of gravity = 32·1695 feet.

(5.) w_0 = Useful work performed $= (2P + p)\,\dfrac{a^2}{2g}$.

w_1, w_2, w_3, w_4, w_5, and w_6 = The work performed by each roll respectively. Corresponding to W_1, W_2, etc.

c_1, c_2, and c_3 = The counter efficiency of the bottom, middle, and top rolls respectively.

E = Efficiency of mill.

The value of R is a difficult thing to obtain accurately, but, since the weight of a cubic foot of cast iron averages 444 lbs., the mean sectional area of the rolls and pinions πR^2, (in square feet), may be obtained approximately by dividing the total weight of the rolls and

pinions by 444 and by the total length of the rolls and pinions (in feet), so that for an approximate value of R, we have the formula,

$$(6.)\qquad R=\sqrt{\frac{W+2W'}{444\pi\,(L+2l)}}$$

Combining this with equation 4, we obtain,

$$(7.)\qquad r^2=\frac{W+2W'}{888\pi\,(L+2l)}.$$

"*Three high*" *Mill.*—The efficiency of the "three high" mill depends upon whether the engine is attached to the bottom or middle pinion, and whether the middle roll is adjustable or fixed in the housings. In the ordinary arrangement, the middle roll is adjustable and the great objection to it is that the upward pressures upon it have to be transmitted through the chucks and journals of the top roll before reaching the housings. The fixed middle roll is a much better arrangement, as both the upward and downward pressures upon it are then transmitted directly to the housings. For the general formula of the efficiency of this mill, therefore, we have,

$$(8.)\qquad E=\frac{(2P+p)\dfrac{a^2}{2g}}{c_1(w_1+w_4)+c_2(w_2+w_5)+c_3(w_3+w_6)+(c_1+c_2+c_3)\;W'T\dfrac{a^2}{2gt}}$$

and since $\dfrac{a^2}{2g}$ is a factor common to w_1, w_2, w_3, etc.; if the component factors—for convenience sake—be denoted by x_1, x_2, x_3, the above equation reduces to,

$$(9.)\qquad E=\frac{(2P+p)}{c_1(x_1+x_4)+c_2(x_2+x_5)+c_3(x_3+x_6)+(c_1+c_2+c_3)\;W'\dfrac{T}{t}}$$

and is modified as follows:

When the engine is attached to the bottom pinion (Eq. 3), $c_1=\dfrac{1}{f}$

$$c_2=\frac{c}{f}=\frac{1+2\pi\dfrac{f'}{n}}{f},\quad c_3=\frac{c^2}{f}=\frac{\left(1+2\pi\dfrac{f'}{n}\right)^2}{f}.$$

When the engine is attached to the middle pinion,

$$c_1=c_3=\frac{c}{f}=\frac{1+2\pi\dfrac{f'}{n}}{f},\qquad c_2=\frac{1}{f}.$$

Case 1.—When the metal is in the lower grooves of the roughing rolls, and the middle roll adjustable—that is, not fixed,

$$x_1 = (P + p) + W_1 \frac{T}{t}.$$

$$x_2 = (P - W_2) + (W_2 + W_3)\left(\frac{T}{t} - 1\right).$$

$$x_3 = (P - W_2) + W_3\left(\frac{T}{t} - 1\right).$$

$$x_4 = W_4 \frac{T}{t}, \quad x_5 = (W_5 + W_6)\frac{T}{t}, \quad x_6 = W_6 \frac{T}{t}.$$

Case 2.—When the metal is in the lower grooves of the roughing rolls and the middle roll fixed, the values of x_1, x_4, and x_6, are the same as in the preceding case, and,

$$x_2 = P + W_2\left(\frac{T}{t} - 2\right), \quad x_3 = W_3 \frac{T}{t}, \quad x_5 = W_5 \frac{T}{t}.$$

Case 3.—When the metal is in the upper grooves of the roughing rolls and the middle roll adjustable, the values of x_4, x_5 and x_6 are the same as in case 1, and,

$$x_1 = W_1 \frac{T}{t}, \quad x_2 = (P + p) + W_2 \frac{T}{t}, \quad x_3 = P + W_3\left(\frac{T}{t} - 2\right).$$

Case 4.—When the metal is in the upper grooves of the roughing rolls, and the middle fixed, the values of x_1, x_2 and x_3 are the same as in the preceding case, and x_4, x_5, and x_6, the same as in case 2.

Case 5. When the metal is in the lower grooves of the finishing rolls, and the middle roll adjustable,

$$x_1 = W_1 \frac{T}{t}. \qquad x_2 = (W_2 + W_3)\frac{T}{t}. \qquad x_3 = W_3 \frac{T}{t}.$$

$$x_4 = (P + p) + W_4 \frac{T}{t}. \quad x_5 = P + W_5\left(\frac{T}{t} - 2\right) + W_6\left(\frac{T}{t} - 1\right).$$

$$x_6 = (P - W_5) + W_6\left(\frac{T}{t} - 1\right).$$

Case 6. When the metal is in the lower grooves of the finishing rolls, and the middle roll fixed, the values of x_1, x_3, and x_4 are the same as in the preceding case, and

$$x_2 = W_2 \frac{T}{t}. \quad x_5 = P + W_5\left(\frac{T}{t} - 2\right). \quad x_6 = W_6 \frac{T}{t}.$$

CASE 7. When the metal is in the upper grooves of the finishing rolls, and the middle roll adjustable, the values of x_1, x_2 and x_3 are the same as in case 5, and

$$x_4 = W_4 \frac{T}{t}. \quad x_5 = (P + p) + W_5 \frac{T}{t}. \quad x_6 = P + W_6 \left(\frac{T}{t} - 2\right).$$

CASE 8. When the metal is in the upper grooves of the finishing rolls, and the middle roll fixed, the values of x_1, x_2, and x_3, are the same as in case 6, and x_4, x_5, and x_6, the same as in the preceding case.

The Clutch Reversing Mill.—In the common clutch reversing mill, five spur wheels are required beside the pinions; two of these are on the same axle and run in opposite directions. To each of these wheels is attached a clawed clutch, the claws of which are placed in opposite directions; and into these claws is moved alternately a clutch, which slides upon feathers fixed to or forged on the main shaft (*Jour. Iron and Steel Institute*, May 1, 1871). Two of the wheels (not on the same axle) are larger than the other three, the arrangement being such that in one direction of rolling, these two always drive the train, while the smaller ones run idle. In the other direction of rolling, the reverse of this is the case. The efficiency at any pass, therefore, will depend upon the direction of the rolling.

Let s_1 and s_2 = The weight each of the two larger wheels.

s_3, s_4 and s_5 = The weight each of the three smaller wheels.

S_1 = The total weight of the two larger wheels.

S_2 = The total weight of the three smaller wheels.

n_1, n_2, &c. = The number of teeth on each wheel respectively, corresponding to s_1, s_2, &c.

a_1, a_2, &c. = The angular velocities of each wheel respectively, corresponding to s_1, s_2, &c.

c' = The counter efficiency of the two larger wheels.

c'' = The counter efficiency of the three smaller wheels.

w' = The work performed against the resistance of the wheels.

Then,

$$(10.) \qquad w' = \left\{ \frac{c'}{f} \left(s_1 a_1^2 + s_2 a_2^2\right) + \frac{c''}{f} \left(s_3 a_3^2 + s_4 a_4^2 + s_5 a_5^2\right) \right\} \frac{t}{2g};$$

in which,

$$(11.) \qquad c' = 1 + \pi f' \left(\frac{1}{n_1} + \frac{1}{n_2}\right),$$

and,

(12.) $$c'' = 1 + \pi f' \left(\frac{1}{n_3} + \frac{1}{n_4} + \frac{1}{n_5}\right).$$

If the two larger wheels are of the same pattern and also the three smaller ones, we have $s_1 = s_2$, $s_3 = s_4 = s_5$, $n_1 = n_2$, $n_3 = n_4 = n_5$, $a_1 = a_2 = a_3 = a_4 = a_5 = a$, and,

(13.) $$w' = \left(\frac{c'}{f} S_1 + \frac{c''}{f} S_2\right) \frac{a^2}{2g},$$

in which,

(14.) $$c' = 1 + 2\pi \frac{f'}{n_1},$$

and,

(15.) $$c'' = 1 + 3\pi \frac{f'}{n_3}.$$

And even if the wheels are all of different patterns, and n_1 and n_3 denote the mean number of teeth on the wheels to which they correspond, equation 13 will be sufficiently accurate for all practical purposes.

Since the moment of inertia of the rolls is (approximately) $\frac{(W + 2W')^2}{888\pi(L + 2l)}$, (Eq. 7), the work performed at each reverse will be $(c_1 + c_3)\frac{(W + 2W')^2}{444\pi(L + 2l)} \frac{a^2}{2g}$. For the efficiency of the mill, therefore, we obtain the general formula, (16.)

$$E = \frac{2P + p}{c_1(x_1 + x_4) + c_3(x_3 + x_6) + (c_1 + c_3) W' + \frac{1}{f}(c'S_1 + c''S_2) + (c_1 + c_3)\frac{(W + 2W')}{444\pi(L + 2l)}}$$

which is modified as follows:

When the two larger wheels are the drivers,

$$c_1 = \frac{c'}{f} = \frac{1 + 2\pi \frac{f'}{n_1}}{f}$$

$$c_3 = \frac{cc'}{f} = \frac{\left(1 + 2\pi \frac{f'}{n}\right)\left(1 + 2\pi \frac{f'}{n_1}\right)}{f}.$$

When the three smaller wheels are the drivers,

$$c_1 = \frac{c''}{f} = \frac{1 + 2\pi \frac{f'}{n_3}}{f}.$$

$$c_3 = \frac{cc''}{f} = -\frac{\left(1 + 2\pi\frac{f'}{n}\right)\left(1 + 3\pi\frac{f'}{n_3}\right)}{f}.$$

CASE 1. When the metal is in the roughing rolls,

$$x_1 = P + p + W. \quad x_3 = P - W_3. \quad x_4 = W_4. \quad x_6 = W_6.$$

CASE 2. When the metal is in the finishing rolls,

$$x_1 = W_1. \quad x_3 = W_3. \quad x_4 = P + p + W_4. \quad x_6 = P - W_6.$$

Ramsbottom's Reversing Mill.—In this mill the fly-wheel is dispensed with altogether, and the boiler is made the sole reservoir of power, so that by reversing the engines, the rolls are reversed at will. The five spur wheels required in the common clutch reversing mill are also dispensed with, and the counter efficiency of the gearing, therefore, is constant. In every instance, we have,

$$c_1 = \frac{1}{f}, \text{ and } c_3 = \frac{c}{f};$$

which gives us for the general formula,

$$(17.) \quad E = \frac{(2P + p)f}{x_1 + x_4 + c(x_3 + x_6) + (1 + c)W' + (1 + c)\frac{(W + 2W')_2}{444\pi(L + 2l)}f}.$$

The values of x_1, x_3, x_4, and x_6 are modified as in the common clutch reversing mill. All the other quantities are constant.

Conclusion.—The above formulæ have been calculated on the assumption that in each instance there are but two sets of rolls, the "roughing" and "finishing;" but it is obvious that they may be easily extended, so as to include three and even more sets. In reducing the above formulæ to figures, the great difficulty is to obtain reliable data. By assuming the requisite data, however, and making it uniform in each case, we may obtain figures which will probably be a fair comparison of their efficiencies. But it seems to us that it would be advisable for some of our iron and steel associations to give each of these and other systems, a fair trial, and so decide the question in a way that admits of no discussion. We have had trials of almost every kind of boiler and steam engine, but none at all of any kind of rolling mill that we are aware of, and we are disposed to believe that the questions connected with the construction of the class

of machinery under consideration, have not received sufficient attention at the hands of really competent engineers.

There is no such thing in existence as a thoroughly good treatise on rolling mill machinery. On the chemical changes wrought in smelting and puddling furnaces, on the character of ores, and the mechanical properties possessed by the finished product, have apparently been concentrated all the energies of those who have made iron and steel their special study; while the details of roll trains have been passed over with very little notice. All that can be learned about the subject from books is embodied in a few desultory chapters and certain sets of engravings, which, however, admirable as drawings, only represent, after all, indifferent practice. The mathematical principles which determine the best forms and proportions to be imparted to the different parts of the mechanism, have been almost entirely ignored. The best literature on the subject is to be found in the engineering periodicals of the day.

Some valuable experiments, however, were recently made by Mr. Rupert Boeck, with the idea of determining the actual amount of power consumed in rolling sheet iron. "The moment of inertia of the fly-wheel, by careful calculation, was found to be 184,516 foot pounds, its weight being 65,300 pounds. The friction of the fly-wheel on its journal alone consumed 16·8 horse power, which, added to the effort required to overcome the friction of the other parts of the mill, gave for the total effort exerted in running the mill empty, 56·5 horse power. The experiments were made on a plate of boiler iron, which had the following dimensions when trimmed: length, 15 feet; width, 41 inches; and thickness, $\frac{1}{2}$ inch. The rolls were nearly 28 inches in diameter."—(See the *Iron Age*, July 23, 1874, page 24.) From the results of these experiments, it seems to be about a fair estimate to assume $P = 50{,}000$ lbs. For the coefficients of friction we have (Haswell) f (cast iron upon brass, tallow unguent) $=$ ·103, and f' (cast iron upon cast iron, soap unguent) $=$ ·197. For the remaining data, let us assume the following convenient and not unreasonable values:

$p = 10{,}000$ lbs, $W_1 = W_2 = W_3$, etc. $= 10{,}000$ lbs, $W' = 1000$ lbs., Length of each roll $= 6$ ft., $l = 1$ ft., $T = 20$ sec., $t = 10$ sec., $n = 20$, $n_1 = 50$, $n_3 = 35$, $S_1 = 4000$ lbs., $S_2 = 5000$ lbs. The efficiency respectively corresponding to each of the preceding cases then will be as follows:

In the "Three-high" mill.	Cases 1 & 5 E =	Cases 2 & 6 E =	Cases 3 & 7 E =	Cases 4 & 8 E =
Eng. attached to bottom pin.,	·038867	·050172	·044828	·04894
" " " middle "	·040096	·051332	·04647	·050904

The average for adjustable middle roll (cases 1, 3, 5 and 7), engine attached to bottom pinion, is 0·041848.

The average for adjustable middle roll, engine attached to middle pinion, is 0·043283.

The average for fixed middle roll (cases 2, 4, 6 and 8), engine attached to bottom pinion, is ·049556.

The average for fixed middle roll, engine attached to middle pinion, is ·051118.

In the Clutch Reversing Mill.	Cases 1 & 2. E =
When the two larger wheels drive, . . .	·045190
" " three smaller " " . . .	·044033

In *Mr. Ramsbottom's Reversing Mill*, cases 1 and 2, E = ·048118.

The ratio, then, of the greatest efficiencies of the three mills respectively in the order of their consideration, is as, ·051118 : ·04519 : ·048118.

Cornish Pumping Engines.—The following is extracted from the *Mining Journal* of April 1, 1876. The number of pumping engines reported for February is 17. They have consumed 1657 tons of coal, and lifted 12,900,000 tons of water 10 fms. high. The average duty of the whole is, therefore, 52,700,000 lbs., lifted 1 ft. high, by the consumption of 112 lbs. of coal. The following engines have exceeded the average duty :—

Crenver and Wheal Abraham—Sturt's 90 in., Millions	63·1
" " " " —Pelly's 80 in., .	52·7
" " " " —Willyam's 70 in., .	79·9
Dolcoath—85 in.	52·7
West Basset—Grenville's 70 in.	53·8
" " —Thomas' 60 in.	58·8
West Tolgus—Richard's 70 in.	53·0
West Wheal Seton—Harvey's 85 in.	62·6

A BATHOMETER.*

The name "Bathometer" has been given by Dr. C. William Siemens to an instrument which he has devised for measuring the depth of sea without using the sounding line, and which has been tested in two transatlantic voyages. The principle upon which the action of this instrument depends is the diminution of the influence of gravitation upon a weighty body, produced by a decrease in the density of the strata immediately below it; thus the density of sea water being about 1·026 and that of the solid constituents which form the crust of the earth about 2·75, it follows that an intervening depth of sea water must exercise a sensible influence upon total gravitation if measured on the surface of the sea.

The amount of this is calculated mathematically in considering the attractive value of any thin slice of substance in a plane perpendicular to the earth's radius, and assuming the earth to be a perfect sphere, unaffected by centrifugal force, and of uniform density. If h represents the vertical distance of such a slice from the point of attraction, then the differential of the attraction of each concentric ring of which such slice is composed is represented by the expression:

$$d^2 A_1 = 2\pi\, d h \,.\, \sin.\, a \,.\, d a \quad . \quad . \quad (1)$$

a being the angle between any ring and the vertical h, which expression when integrated between the limits h and a, and a and o, gives

$$A_1 = 2\pi h \left(1 - \tfrac{2}{3}\sqrt{\frac{h}{2R}}\right) \quad . \quad . \quad . \quad (2)$$

in which for small values of h the factor $\sqrt{\frac{h}{2R}}$ may be neglected, when the formula assumes the form

$$A_1 = 2\pi h \quad . \quad . \quad . \quad . \quad (3)$$

in which A_1 represents the total attraction to the depth h.

The total attraction of the whole earth is obtained in substituting R for h in (2) when the following proportion is obtained:

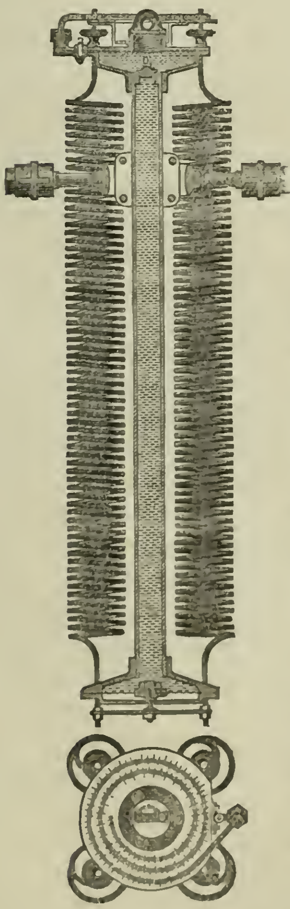
$$A_1 : A = 2\pi h : \tfrac{4}{3}\pi R \text{ or} = h : \tfrac{2}{3} R.$$

It follows that if sea water was without weight, the total attraction of the earth as measured upon the sea surface, would diminish in the proportion of the depth to $\frac{2}{3}$ R; but taking the weight of sea water into account, gravity is found to diminish upon the sea level in the proportion of the depth to $\frac{35}{43}$ R or as .8 R, this proportion would be strictly correct if the interior of the earth was of the same density as

* From *Engineering*, March 31, 1876.

surface rock, but the coefficient here arrived at has to be diminished in the proportion of the density of surface rock to the mean density of the earth or in the proportion of about $\frac{2 \cdot 75}{5 \cdot 4}$. It is safer, however, not to rely entirely upon these mathematical deductions in constructing a working scale, which it is preferable to base upon comparison with the sounding line.

It may be remembered that in 1859, Dr. Siemens proposed an analogous method of obtaining soundings, and made an attempt to construct an instrument which should indicate such slight variations in total gravitation as would require to be measured, but the difficulties connected with neutralizing the effects of the variation in temperature, and motion of the ship, were found to be very great. Within the last year, however, the exigencies of deep sea telegraph construction have shown the value, and indeed almost the necessity of having a depth indicator always to hand, and hence the instrument of which we give a diagram to our readers, not showing details but only the principle of action.



It consists essentially of a vertical column of mercury contained in a vertical steel tube having cup-like extensions. The lower portion is closed by means of a corrugated steel plate diaphragm, similar in construction to those employed in aneroid barometers, and the weight of the mercury is balanced in the centre of the diaphragm, by the elastic force of carefully tempered steel springs whose length is the same as that of the mercury column. Both ends of the column are open to the atmosphere, so that its variations of pressure do not affect the readings of the instrument.

The elasticity of carefully tempered steel springs having been found by experiment to diminish in an arithmetical ratio with rise of

temperature, but in a different ratio to that of the dilatation and consequent diminution of the density of mercury, this had to be arranged for in the mechanical arrangement of the instrument. It is evident that if the mercury were contained in a cylindrical vessel not varying in diameter, its potential would always be sensibly constant. If, on the other hand, two cups were connected by a tube of infinitely small diameter, the potential would diminish with rise of temperature in the ratio of the expansion of mercury. The form employed in the instrument is a mean between these extreme forms, the ratio between the areas of the cups and that of the tube being governed by that of the diminution of the density of the mercury and potential of the springs.

The tube is throttled near its upper extremity, in order to diminish the influence of the ship's motion in causing vertical oscillations of the mercury. The instrument is suspended in a universal joint, a short distance above its centre of gravity, in order to cause it to retain a vertical position notwithstanding the oscillations of the vessel, and it is contained in an air-tight casing so as to be unaffected by atmospheric influences.

The reading of the instrument was effected by means of electric contact between the centre of the diaphragm and the end of a micrometer screw, the divisions on the rim and the pitch of the screw being so proportioned, that each division represents one fathom of depth. Another mode of reading the instrument by means of a spiral glass tube fixed on the top of the instrument, and connected with the mercury in the upper cup by means of a liquid of less density is now employed, and has been found to be successful in practice.

The indications of this instrument have been compared with soundings taken by means of Sir William Thomson's steel wire apparatus, and show a very close accordance. The following shows what kind of indications it has given. On the 31st of October, 1875, according to soundings, the Faraday was at noon in 82 fathoms, at 1.8 P. M. in 204 fathoms, and at 2.20 P. M. in 69 fathoms of water, whilst the bathometer readings were 82, 218, and 78, showing that the instrument indicated a passage from shallow into deep water and back into shallow in a period of two hours with considerable accuracy.

The instrument is also applicable for measuring heights above the surface of the earth, such as balloon ascents, but its indications of the height of mountains or elevated plateaus would be affected by the attraction of the elevated land, varying with its surface, and the in-

strument is not therefore considered reliable for such purposes. In the use of this instrument, the chief disturbing influence is the effect of variation of latitude upon the earth's attraction, varying as the square of the sine of the latitude, the difference between the equatorial and polar attraction as established by pendulum observation being $\frac{1}{180}$th of the former. The amount of this correction would be calculated as depth in fathoms and tabulated for use with the instrument.

The instrument would be chiefly useful in enabling the mariner to determine his position, when in foggy or cloudy weather he was unable to take observations. If the figure of the ocean bed was laid down more perfectly than at present upon charts, and such were in the hands of the mariner, he would be able to tell in observing his bathometer what was the approximate depth of water below him, and the direction in which, and the rate at which the depth either increased or diminished, while by consulting his chart he would then be enabled to determine his actual position with considerable accuracy.

DESCRIPTION OF AN IMPROVED FORM OF GOVERNOR FOR STEAM ENGINES OR OTHER PRIME MOVERS.

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In the writer's experience as a practical mechanic, his attention has often been called to the irregularities of the *best forms* of governors, whose action is dependent upon the centrifugal of the revolving pendulum; even after all that years of experience and most careful study have done for their greater accuracy of performance.

By this means he was led to give some thought to the requisites of a governor, which would be nearly, if not quite, isochronal in its action.

A careful study of the ordinary form of ball governor, convinced him that a governor such as was needed, must satisfy the following conditions:—

1. The motion of the valve must precede any change of speed in the governor balls; otherwise, as in the case of all centrifugal governors, the engine must go fast in order to go slow, or the reverse. Should the valve motion follow or be coincident with a change of

speed in the governor, the engine's governor necessarily must vary for some interval of time, and the governor cannot be isochronous, because of a *defect of principle.* When, however, the valve motion can be made to precede a change of speed in the balls, the engine is so to speak, barred from any variation of speed upon making the attempt, and rendered practically isochronous.

2. The opening of the steam valve must be independent of the angle, which the arms attached to the balls, form with the central spindle, around which they revolve.

Thus an engine having its full amount of work, and governed by an ordinary ball governor, will be kept at a uniform speed by the governor so long as the average resistance to be overcome by the engine remains constant, but whenever any of the work is taken off, the speed of the engine will be increased to a higher rate, corresponding to the diminished work, and at this faster speed the engine will then run uniformly under the mastery of the governor, so long as the work continues without further alteration. This arises from the fact that the degree of opening of the steam valve is directly controlled by the angle to which the governor balls are raised by their velocity of revolution; the steam valve being moved only by a change of speed, and consequently by a change of the angle of suspension of the governor balls; whence it follows that a larger supply of steam for overcoming any increase of work can be obtained only, in conjunction with a smaller angle of the suspension rods of the governor balls, and consequently with a slower speed; and that a larger angle of the ball rods, and consequently a higher speed, must be attained in order to reduce the supply of steam for meeting any reduction of work to be done by the engine.

3. The governor must be sensitive, *i. e.*, quick to act. This result is usually attained in the centrifugal governor, by giving to the balls a speed much greater than that of the engine, so that a slight variation of speed in the engine is multiplied in the governor many times.

A high speed, however, is attended with the disadvantage of rapid wear, and in the case of an ordinary governor, wear, such as to admit of any lost motion, is attended with much trouble to the engineer, and sudden variations of speed in the engine.

4. The governor must have power, which means an even and sure motion of the valve, notwithstanding the almost unavoidable defects of workmanship, such as the sticking of the valve, or the binding of the valve stem through careless packing of the stuffing box. In the

ordinary governor this power is sought to be obtained either by a high speed, the defects of which have already been pointed out, or by means of very heavy balls, which results in a very cumbersome and large machine, besides adding largely to the expense.

5. Simplicity and economy must be attained in the construction and manufacture of the governor, otherwise the greater number of mechanics will prefer to use the ordinary form of governor, on account of its lesser cost—first cost often being an item much more regarded by mechanics than a true and intelligent spirit of economy would dictate.

A careful study of these before mentioned facts, shows that absolutely isochronous motion of the engine is unattainable, as the ability of the governor to regulate the speed of the engine is derived entirely from variations of the speed of the engine from any fixed rate, but it is quite possible to arrange so that the governor itself may be practically isochronous, and thus create a standard of speed to which the engine must conform, more or less nearly, according to the sensitiveness and power of the governor used.

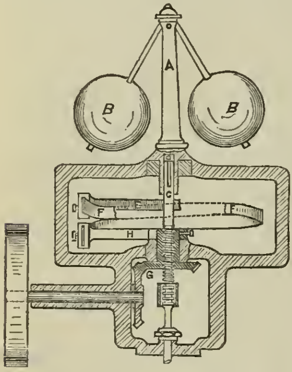
This result I have endeavored to obtain by the use of the inertia of the balls of the free conical pendulum, in connection with a spiral spring and screw.

In this improved governor which I call isochronous, the pendulum spindle is in two sections, of which the lower one, to which, by means of a feather and key way, the driving power is geared, is capable of sliding lengthwise a little, at the same time that it turns the upper one, and screw up and down in the hub of its driving wheel; and is connected to the wheel by a spring which allows the wheel to over-run the spindle a little, when the motion increases to close the valve, in advance of any change of speed in the pendulum; and when the speed of the engine slacks, the tension of the spring will make the spindle over-run the wheel, which will screw the spindle along the other way, and thus open the valve in advance, of any change of speed in the pendulum; thus making a much more sensitive governor than others now in use.

The sensitiveness of this governor is determined by the flexibility of the spring used; the more flexible the spring, the more sensitive the governor to any variations of speed in the engine. The power to move the valve with evenness, is derived from the screw, the pitch of which determines its power.

The spiral spring may have more than one coil, as shown in the drawing, which, while giving more sensitiveness to the governor, also gives greater power, because of permitting greater angular separation of the ends of the spring, and also admits of a less pitch to the screw, and consequently greater power to move the valve, when the distance, through which it is to be moved, is the same.

The figure shown is a partial sectional elevation; *A* is the upper section of the spindle carrying the free conical pendulum *B; C* is the lower section to which the power through the spring *F* is connected. It enters a socket *D* in the upper section, and is capable of sliding lengthwise therein a little. It also carries an arm *E*, to the outer end of which is attached the upper end of the coiled spring *F;* whose other end is connected to the hub of the driving wheel *G*, by the arm *H;* to allow the driving wheel to advance faster than the spindle for a short time, when the speed suddenly increases; and fall behind it when the speed slackens, in order to screw the spindle up or down by its threaded portion *I*, in the screw threaded hub of the driving wheel, and thus shift the valve up or down.



The power of this governor is only limited by the strength of the working parts, ball rods, spring, etc. Should the spring break under any unexpected strain, the immediate closing of the steam valve will result, as the screw threaded spindle will be at once screwed down to its fullest extent.

That this governor should have so great power, is not surprising, when it is seen that the inertia of the balls is used as a "point d'apui," from which the valve is worked, and that instead of making use of centrifugal force only, as hitherto, the whole inertia of the free conical pendulum is used. For the sake of clearness, it must be especially noted that the balls *B B* are connected only to the central spindle *A* by a pin at the top, and that their centrifugal force is not made use of in this governor.

The calculations of the dimensions of the governors, which are quite voluminous, are not added to this paper, as the principle can be clearly understood without formulæ by inspection of the drawing.

THE SCHUYLKILL RIVER.

Gauging its Flow—Deposits in the Dam—Value of Fairmount Water Power.

Robert Briggs, C.E., *Editor* Journal of Franklin Institute:

Dear Sir :—In answer to your letter, inquiring the actual relation which the water passing Fairmount Dam bears to the rain-fall upon the entire drainage area, and the further utilization of the water power of the river, I would state that the relation existing between the rain-fall on the Schuylkill basin, and the water discharged at Fairmount, has never been definitely determined.

Prior to my retirement from the management of the water department, considerable preliminary work had been done, and a plan had been matured for a thorough investigation of the hydrography of the Schuylkill Valley, which would have given accurate data for ascertaining all the characteristics of the stream and its basin. The work accomplished may be briefly summarized as follows:

"*A.*" The records of rain-fall upon the area drained, which were made by various observers, were collected and tabulated. Rain gauges were located in places where none had been placed before, and which were necessary to the proper examination of the subject.

"*B.*" A gauge was constructed with a vernier reading to the thousandth part of a foot, and located beyond the influence of the Fairmount Water Works, so as to measure the flow of water over the comb of the dam. Frequent readings of this gauge were taken.

For a number of years, measurements had been made, and records kept of the flow of water over the dam, but they were unreliable because they were taken from a cast iron gauge, permanently secured to the masonry of the gate bridge, possessing the following defects: 1st. The zero point did not coincide with the level of the dam. 2d. The markings were only in inches, and these were incorrectly spaced. 3d. It was so located that an observer could not get close enough to it for accurate reading. 4th. Being situated in the fore-bay, the gauge was influenced by the operation, starting or stopping of the wheels. 5th. The readings had been taken but twice in a day.

"*C.*" The flow of water over the dam was found to be influenced by the operation of the wheels of the water works, and of the factories at the Falls and Manayunk, and also by the lockage of boats, and the direction and intensity of the wind. It was, therefore, evident that no record but a continuous one would represent the daily average, and to secure such a record, an automatic recording gauge,

operated by clock work, was designed, to be used in connection with the vernier gauge described. This vernier gauge is removed, and measurements are now made, and records kept from the defective cast iron gauge mentioned.

"*D.*" In connection with readings of the vernier gauge, a series of observations to determine the velocity of the surface of the stream between Fairmount Dam and Columbia bridge, was made with floats.

A number of cross sections of the stream had been previously surveyed, and the mean prism of the stream ascertained. Calculations based upon these observations were made, which demonstrated the flow of the river, when free from storm water, to be six hundred and fifty millions (650,000,000) gallons per day, representing an available power at Fairmount, of one thousand (1000) horse power.

"*E.*" Accurate hydrographical surveys were made of Fairmount Dam. Prominent features, rocks, etc., were located by triangulation, and the shore line fixed by ordinates, from lines connecting points of triangulation. Cross sections of the stream were taken every 500 feet, the soundings being made 20 feet apart, on these lines. These surveys were made in the years 1861, 1864 and 1866, and the maps showing their details are now in the possession of the Water Department. From these surveys, the estimates of the accumulation of deposit in the lower portion of Fairmount pool were made. In the section between Columbia bridge and Fairmount Dam (a distance of 8750 feet), with a water surface of $168\frac{1}{3}$ acres, the deposit from 1861 to 1864 amounted to 3,313,681 cubic feet, and from 1864 to 1876, the accumulation increased by 6,642,584 cubic feet, making a total of 9,956,270 cubic feet, equivalent to a daily average deposit of 5430 cubic feet. In the same time (from 1861 to 1866), the water surface in this section of the pool was reduced 15·76 acres. The mean sectional area of this portion of Fairmount pool, was correspondingly decreased:

In	1861,	it was	8254	square	feet.
"	1864,	" "	8153	"	"
"	1866,	" "	8087	"	"

Along the the towing path in front of the zoological garden, now about 450 feet inland, there was, in 1850, six feet of water. For further data, I refer you to my report to Philadelphia City Councils, 1867, pages 63 67.

Utilization of the Water Power.—The only reserve power for Fairmount Water Works in the control of the city, is produced by flush boards, placed on the dam in seasons of low water, and even the right to use this reserve has been questioned by the Schuylkill Navigation Company, when they require it for the passage of boats. This company places similar bounds on all their dams in summer.

Commercial Value of Fairmount Water Power.—In some of the annual reports made to City Councils, the assertion is made that water is pumped at a less cost at Fairmount, than at any of the steam pumping works in the city. And this is true if only the incidental running expenses are considered, and no account taken of the cost of the water power. But if to the expenses is added interest on the cost of water power, then it becomes evident that it would have been true economy to have continued pumping by steam power.

The water rights, damages, dam, fore-bay (machinery excepted), cost originally, when the water power works were first put in operation, in 1822, about $400,000. See report of Watering Committee, 1837, page 7. At that time, the daily demand of the city approximated one million gallons. The power to pump that amount of water cost, therefore, $24,000 per year, the interest on the cost of the water power. To develop the power required to pump this amount of water with the Oliver Evans engine, then at Fairmount, would have consumed 1587 cords of wood, which, at $7 per cord, the price stated at that time, would have amounted to $11,109 per annum. See report on the water power of the River Schuylkill, 1820, page 8.

The use of water power at that time, therefore, was at a loss to the city, of nearly $13,000 per annum, and at the present time the loss each year is still greater. The present cost of Fairmount Water Works, exclusive of machinery, is over one million dollars. (In this amount, the enormous damages for which the city has been mulcted on account of water power being taken in times of drought, are not included.) The interest of one million dollars, at 6 per cent., makes the annual cost of the water power $60,000.

During 1874, the amount of water raised by the Fairmount works averaged 21,504,736 gallons per day. To raise this amount of water at the Schuylkill works (using the operations of these works in 1874 as a basis), would have consumed 8300 tons of coal, which, at $4.88 per ton (the price then paid), would amount to $40,504, showing a loss of $19,500 by the use of water power, as compared with steam. With allowance made for the portion of the supply delivered into the lower (Fairmount) reservoirs, this loss will be further augmented. The ordinary expenses of operating the water power machinery, are much less than those required for the maintainence of the steam pumping machinery, but the expenditures for repairs and renewals, being, of necessity, heavy for water power, will average much more than the expenses of repairs and renewals required for steam power works.

The further utilization or increase of the pumping capacity at Fairmount by water power, cannot but be at an expenditure in excess of what the increase will warrant. The last improvement of

substituting turbine wheels for the old breast wheels, at a great cost, has not increased the pumping capacity of these works; this is, however, largely due to defective proportion and arrangement of the wheels and pumps. It is doubtful if any addition to the capacity of Fairmount works can be made as cheaply by water power as by steam. The dam could be raised two feet at a comparatively small expense, which would increase the storage capacity of Fairmount pool 200,000,000 gallons, and the additional head would augment the power of the works sixteen per cent. (if the navigation company would allow the city to use this impounded water in times of drought).

Although the city is the riparian owner of most of the property which would be affected by this increase in height of the dam, the expenses incident to the work, and the increased risks, would not warrant the execution of this project. One of the prominent advantages claimed for the great reservoir in course of construction in the East Park is to increase the capacity of Fairmount works by storing the water pumped into it when the river is running full, to utilize in times of scarcity. No figures are necessary to demonstrate that the expenditure of millions for such a purpose, is a mere waste of money. It is doubtful if the annual saving in pumping would cover the interest on the cost of a proper main to connect the works and reservoir.

Neither would the construction of impounding reservoirs, as has been proposed, prove remunerative. The site selected for the great reservoir which was proposed as a part of the plan for supplying the city by gravitation from the Perkiomen, is undoubtedly the most advantageous location for storing a large volume of water, at comparatively small expense in the drainage area of the Schuylkill; its estimated cost was $500,000. If its storage could be utilized to fifteen billion gallons per annum, to augment the power at Fairmount in times of low water, it would only increase the pumping power one billion gallons, an amount which could be pumped with $5000 worth of coal, at present prices, using the best pumping machinery now in use by the city. The figures in these estimates are based upon the operation of the steam machinery now in use by the city, most of which can hardly rank as fair, as far as economy of fuel is concerned. It is possible to so alter or replace the machinery employed, as to save one-half the fuel now consumed, and make a corresponding reduction of the cost of pumping by steam.

Yours, Respectfully,

H. P. M. Birkinbine,

Philadelphia, March 29th, 1876. 152 S. 4th Street.

THE NAUTRIGON, AND SUMNER'S METHOD FOR DETERMINING A SHIP'S POSITION.*

By Bernard R. Greene, C. E.

This word, though not familiar, is doubtless destined soon to become so amongst navigators, as it is the title of a new nautical instrument recently patented by Rev. Dr. Thomas Hill, the well known mathematician, ex-President of Harvard University, and now of Portland, Maine.

It is intended as a companion to the sextant and chronometer, and is designed chiefly to ensure the rapid and accurate determination of a ship's position at sea by Capt. Thomas H. Sumner's method, now extensively used. As the beauty of both the method and the instrument has won the admiration of the writer, it was thought that a sketch of them in the columns of the *News* might prove interesting to many engineers, who, though not expecting to be immediately called upon to survey a trail upon the trackless ocean, are always ready to listen to an explanation of any new short cut to the solution of a problem, that will eliminate all appreciable errors.

Generally when the latitude is not correctly known, the longitude by chronometer will necessarily be in error, but the Sumner method furnishes the means, when the chronometer has correct Greenwich time, of ascertaining the ship's position, as a point can be determined by the intersection of two straight lines upon a Mercator chart. Observations can be taken at any time of the day or night, when an opening in the clouds reveals a known and favorably situated heavenly body, and the horizon is not too much obscured. The method depends upon the determination of one or two circles of equal altitudes of the sun (or other heavenly body) which are circles upon the earth's surface whose centres lie in a line joining the centre of the earth with the sun, or, in other words, they are like the circles of latitude, their poles being the points upon the earth's surface at which, at the time of observation, the sun is vertical. This system of circles changes with the diurnal revolution of the earth and the declination of the sun.

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* From *Engineering News*, Chicago, April 22d, 1876.

As the ship from which an altitude observation is taken will be somewhere upon one of these circles, it is evident that if two circles are determined at such an interval of time as will allow the sun a sufficient change of azimuth, their intersection upon the surface of the globe will be her true place if she has not moved during the interval. If she has moved, then the bearing and distance by dead reckoning of her last from her first position is to be laid off from any point of the first circle, and through the point thus found a circle of the earth drawn parallel to the first circle will intersect the second at her last position. Completing the spherical parallelogram by a line from the last point, her first position is found upon the first circle.

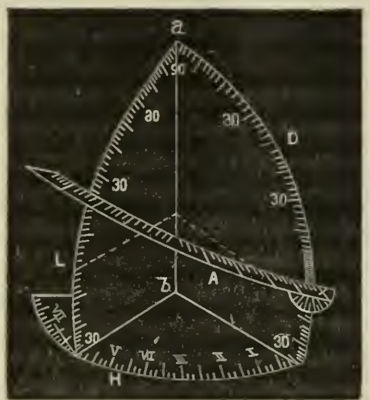
A circle of equal altitudes is ordinarily determined as follows: As, by dead reckoning, the navigator always has an approximate knowledge of his latitude, he now assumes it to be, say, 30′ greater, takes the altitude of the sun by the sextant, its declination from the Nautical Almanac, Greenwich time from the chronometer, and works up his longitude. The position thus obtained is projected upon a Mercator chart. Next, assuming a latitude 1°, more or less, smaller than before, the other data remaining the same, he works up a new longitude, and projects a second point upon the chart. As the same altitude was used it is evident that these two points lie in a circle of equal altitudes, which, within limits of two or three degrees, will be practically a straight line. Therefore, through the two points upon the chart is drawn a straight line, upon which the ship must be somewhere. The bearing of any land intersected by the prolongation of this line is at once found, while both bearing and distance to any shore lying parallel and opposite to it are also found. After a sufficient lapse of time, say one to three hours, a second altitude is obtained, and, with the same assumed latitudes, two other points are projected upon the chart and a second line containing the ship's position is drawn.

These computations include four separate though similar problems, many searchings in tables of logarithms and corrections; and involve so much ciphering as to be, therefore, liable to error, especially at the hands of men of moderate skill in calculation.

Suppose now that it is desired to correct the compass. Either of the two lines plotted upon the chart being practically perpendicular to the direction of the sun at the time of the corresponding observa-

tion, it is evident that if the *compass* bearing of the sun had been taken at the same time it could now be compared with the *true* bearing of the line on the chart, by making allowance for the difference of 90°.

The nautrigon, as shown in the figure, consists in principle of four arcs of circles. D, the declination arc; L, the latitude arc; H, the



lower arc; and A, the altitude arc. D, L and A, represent arcs of great circles of the earth, the first two being meridians, while H is an arc of a parallel of south latitude, placed in this instrument at 30°. This combination is, in short, a skeleton of less than one-third of a globe. The planes of D and L are hinged on the line *a b* representing the earth's axis, *a* being the north pole, while the plane of D is permanently attached perpendicularly to the plane of H, leaving L free to revolve over it.

D is provided with a vernier, carrying at its zero a short projecting pin which always points to the zenith, while A is detached and provided at one extremity with a half compass card whose centre is a hole fitting nicely over the vernier pin. D and L are each 120°, graduated from the equator 90° north and 30° south; A is 90°, graduated with the 90° mark at the compass; and H is 120° divided into eight hours, with subdivisions for minutes and seconds.

Now let us see what assistance may be rendered by the nautrigon in the above computations. Take the altitude of the sun simultaneously with the time by chronometer. Apply to the altitude the tabular corrections for sun's semi-diameter, dip of the horizon,

refraction and parallax, the joint effect of which is usually given in one table and may be applied as a single correction. Set and clamp the vernier at the declination of the sun taken from the nautical almanac, thus bringing the pin directly under the sun, the declination arc representing the sun's meridian at the time of observation. Attach the altitude arc to the vernier pin, and swing both this and the latitude arc to intersect each other respectively at the assumed latitude and corrected altitude. The latitude arc then stands upon the hour arc at the exact number of hours and minutes before or after noon when the observation was taken. This reading, corrected for mean time as usual, compared with the chronometer time, and 15° of longitude allowed for each degree of the difference, gives the longitude corresponding to the assumed latitude. Assume a second latitude, a degree or so lower than the first, swing the altitude and latitude arcs to intersect, read off the time as before and get the second longitude. Two points are now determined, in a line passing through the ship, which may be projected upon the chart.

As two or three subtractions and multiplications with small numbers constitute the ciphering for each position, much of which may be done mentally, it would seem that, until there is established upon the ocean highway a better system of guide boards than now exists in the sun and stars, the operations for finding a ship's position will never be simpler than these.

By means of the half compass card of the nautrigon the compass variation is readily obtained. For, having taken the compass bearing of the sun at the time, say, of the first observation, arcs A and L are now set to intersect at the *true* bearing of the sun read upon the compass card.

In south latitudes this instrument is to be imagined as inverted, the north pole becoming the south pole.

Although its design was suggested by the Sumner method, the utility of the nautrigon is not thus limited. It will save a large amount of computation in great circle sailing, when the course to be steered at the several verifications of position may be at once read off the compass card without calculation. It is also useful in the solution of any problem involving a spherical triangle. Tests with a completed instrument have given most satisfactory results.

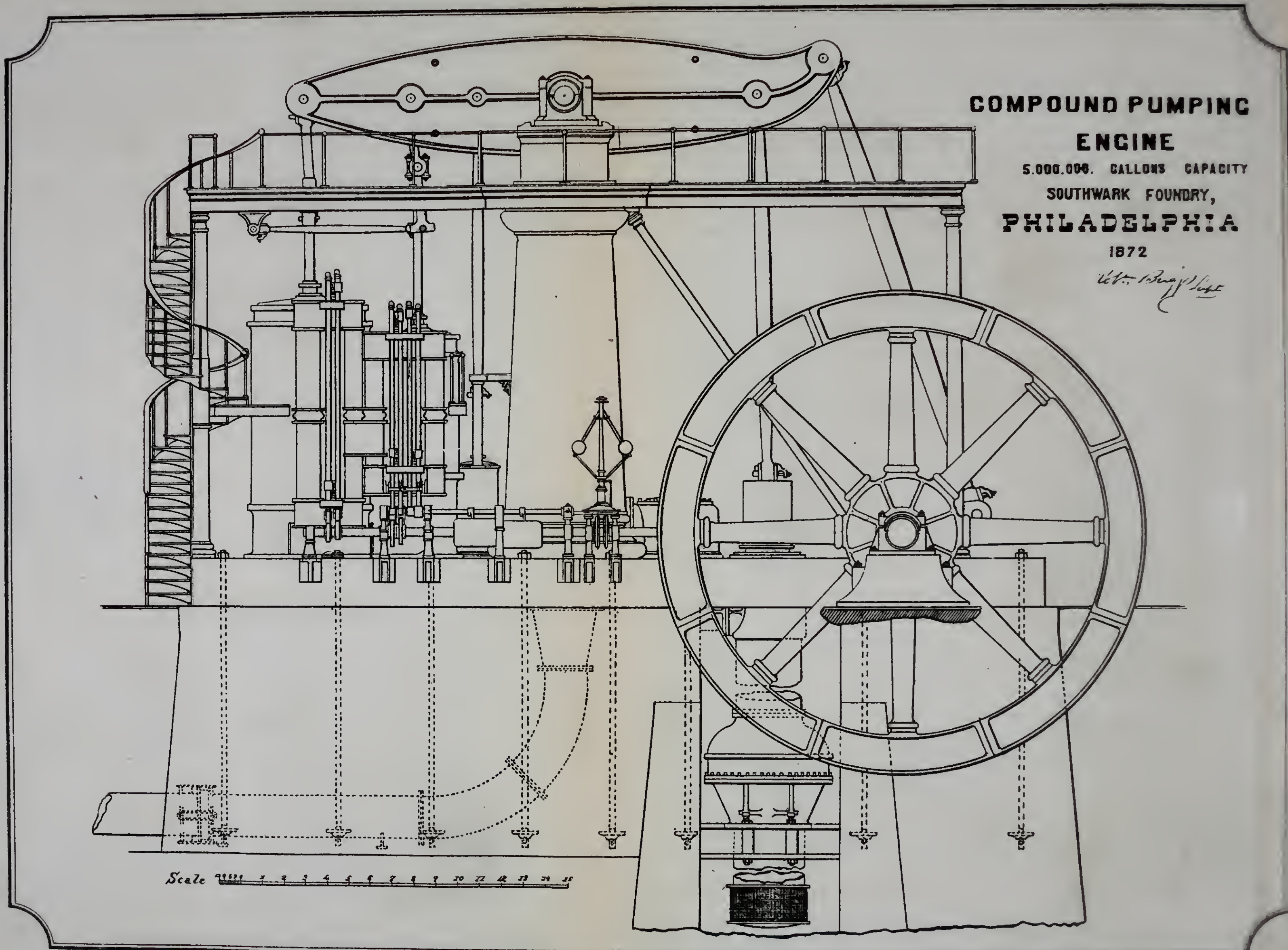


Photo Litho & Printed by J. H. Camp [illegible] Philada.

THE ENGINE FOR THE LOWELL WATER WORKS, CONSTRUCTED FOR THE CITY OF LOWELL, MASS., 1871-2.

J. P. DAVIS, C.E., Engineer Lowell Water Commissioners.
Designed by ROBERT BRIGGS, C.E.

The Engine for the Lowell water works was constructed to Proposals issued by the Board of Water Commissioners of Lowell, which, with general specifications, were prepared by the Engineer for the Commissioners. The type of engine and its requirements in performance, and the controlling strength of parts were given, but both proposals and specifications left the design of the engine in the main in the hands of the bidder, and the following gives the result as erected by the Southwark Foundry,—Henry G. Morris, proprietor,—of which establishment the writer was at the time superintendent.

This engine is peculiar in the United States as being, without material change, a specimen of the " Simpson " pumping engine of England. Its performance in duty of pumping has compared favorably with the reported standard of that engine. A full account of performance, together with a statement of the figures of construction, will be found in the JOURNAL, Vol. C, page 305, where is also given the specification for the boilers,—accompanying the engine, with plate.

SPECIFICATION OF A PUMPING ENGINE FOR THE CITY OF LOWELL, MASS.

To consist of—

ONE BEAM PUMPING ENGINE, with two steam cylinders (one high pressure and one low pressure) with air pump and condenser on one arm of beam; and bucket and plunger, lift and force water pump, and fly wheel on the other arm of beam.

The dimensions and proportions of the parts are of sufficient size when working at the lowest probable duty of seventy-five millions, (American standard) to raise at least five millions U. S. gallons through a twenty-four inch main of about twenty-five hundred feet length to the height of one hundred and fifty-seven feet above level of supply.

GENERAL DESCRIPTION OF PARTS OF THE ENGINE.

There will be one main cast iron bed-plate (cast in two pieces), which will form the base, and excepting only the outside pillow block

of the fly wheel shaft, will carry and sustain independently from any other foundation or attachment, all the parts of the machine.

The main central column will be of such magnitude and strength as to be free from vibration when the engine is working with its maximum load, and will form the air chamber of three hundred and sixty feet contents above the delivery valve; four smaller columns from the corner of the bed-plate will sustain a (comparatively) light entablature which shall join into the capital of the main column; this entablature will serve to carry the anchor block of the parallel motion, and also as a platform around the upper moving parts of the engine. The pedestals for the beam pillow-block, will rest upon the capital of the central column. The style of the engine, architecturally, will be based upon the Roman-Doric example.

The beam will be double and of ample strength; the fly wheel end being curved upwards to preserve the equality of length of main centres of the beam, when the fly wheel shaft is moved outwards from the centre of the bed-plate, so as to allow the pump to be placed between the crank and the base of the central column.

The steam cylinders will be compound or high and low pressure, and will have such relative areas as to expand the steam eight times when it is cut off in the high pressure cylinder at seven-sixteenths ($\frac{7}{16}$) the stroke. They will be cast from hard metal and steam jacketed all over, including heads and bottoms.

The low pressure cylinder will be placed at the extreme end of the beam, the high pressure cylinder being as close to it as can be arranged, so as to give the shortest steam connections. The cylinders will be carefully jacketed all over by a porous jacketing, outside of which will be heavy felt, encased in black walnut staves, with mouldings at base and top, and brass bands.

The heads will be covered with polished bonnets.

The valves will be balanced double-beat poppet, or balanced double-beat lantern ones, as preferred by the engineer.

The side pipes will have copper expansion rings to connect to the upper steam chests, and the supply side pipe to low pressure cylinder will have a copper expansion ring where connected to lower steam chest.

The cross over is effected by a twisted passage in the chest in centre of high pressure exhaust and low pressure side pipes. The side pipes will be covered in a similar manner to the steam cylinder.

All the steam valves will be moved by a cam shaft along the side of the engine, with cams acting upon rollers on rockshaft arms with lifters and lifter rods. The cams which move the steam valves will be made long and of the proper shape to be moved endwise upon the cam shaft as regulated by the governor, forming a variable cut-off after the German method. (The cam shaft will be tubular and the motion of the cut-off cams will be effected by a central rod.)

The variation of cut-off will be from two-tenths ($\frac{2}{10}$) to eight-tenths ($\frac{8}{10}$) the stroke of the high pressure cylinder.

The air pump will be of the usual character with rubber valves on brass gratings. The air pump will have a crosshead and slides in place of being attached to the parallel motion. The condenser will be of the ordinary jet type, aud will have ample dimensions (together with the air pump), for establishing and preserving the vacuum in the low pressure cylinder. Upon one side of the air pump will be attached a brass force air pump for supplying the air vessel, and for replacing the air absorbed by the water. Upon the other side of the air pump will be placed the force feed-water pump; these two pumps will be worked from the ends of the air pump crosshead.

The fly wheel connection is taken from the opposite extremity of the beam from the cylinders.

The fly wheel will be made in segments with bolts through the arms. The crank will be balanced on the fly wheel hub. All the moving parts will be balanced in the beam.

The pump will be "bucket and plunger" with one supply and two deliveries on each stroke; the relative area of bucket and plunger being such that there shall be, as near as possible, an equality of labor on each half of the motion. The pump will have either slides or a trunk connection, as desired by the engineer. The gib and key will be above the top of plunger. The trunk will be removable from the plunger.

The pump depends from the bed-plate, and the suction valve chamber will be attached to the body of the pump.

The arrangement will be such that by breaking the joint with the delivery valve chamber and that from the suction valve chamber to supply pipe, the pump with all its parts can be lifted out directly through the bed-plate. The delivery valve will be in a separate chamber placed on the bed-plate between the pump and the central column, and will be accessible by lifting a cover. A by-pass, with valve, will

be placed on the pump to relieve the engine at starting. The suction valve will be double or triple beat (as preferred by the engineer), one and one-fourth ($1\frac{1}{4}$) times the area of the pump.* The bucket valve will be double beat. The bucket will have a broad surface with grooves in lieu of packing, and the delivery valve will be three beat and equal in area to a twenty-four inch pipe. The upper joint of the air-chamber will be perfectly air tight under sixty pounds pressure of air. The discharge pipe from the air-chamber will be provided with a twenty-four inch stop valve, and a thirty-six by twenty-four inch Tee will be placed in the passage under central column, or such other provisions will be made for this part of the machine as the circumstances may require. The supply pipe of thirty-six inches diameter and not over twelve feet in length will be furnished.

The main steam pipe will be of ample dimensions, and there will be an independent and separate supply steam pipe from the boilers to the jackets. Both main and supply steam pipes will be covered by porous materials, felting and walnut lagging with brass bands. There will be a return condensed water pipe from the jackets to the boilers, if they are low enough for the water to flow, or to a trap with connection to the hot well if not. There will be suitable injection valves and pipe connection to a point of supply within the engine room, and an overflow pipe from hot well to any point not beyond the wall of building. Man-holes will be provided for the air vessel, the supply valve and at any other point where occasional access is desirable.

There will be placed upon the outside main pedestal, a ball governor to regulate and render automatic the variable cut-off. The outside pedestal will be supported by a box bed-plate. All the necessary foundation bolts and washers to secure the engine to the masonry will be supplied.

There will be cast iron galleries around tops of the cylinders and upon the entablature, and a staircase from the floor, with finished hand-rails and stanchions. Cast iron floor-plates will cover all the openings in the bed-plate.

An enclosed space around the fly wheel and engine will be formed by a finished hand-rail with stanchions made to secure to the floor of engine room.

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* This was changed afterwards to an arrangement of seven double beat valves in the suction chamber, and four double beat valves in the delivery chamber.

There will be provided, and suitably attached or mounted, two Richard's Indicators, one Bourbon steam gauge, one Bourbon vacuum gauge, one water pressure gauge, one air level glass gauge; also, in walnut cabinet case, a complete set of steel spanner wrenches which shall "take" all the bolts and nuts.

Three bright screw wrenches, a set of chisels, a set of hand hammers and sledges, also one pair three-fold iron blocks, with thirty fathoms of six and one-fourth ($6\frac{1}{4}$) inch manilla rope, one pair Weston's differential blocks for five tons, one pair same for one ton, also all the levers and tools required for ordinary use about the machinery. There will be provided as duplicates, one set of spare brasses for the connecting and pump rods and main links, one complete set of spare gum valves for air pump, and a spare valve for both suction and delivery of main pump. All journals will be provided with suitable oil cups and drip pans, and there will be suitable pipes and pans for conveying the condensed water from the stuffing boxes.

PARTICULAR DESCRIPTION OF PARTS OF ENGINE.

BED-PLATE, will be 45 feet long by 8 feet 6 inches wide by 2 feet 6 inches deep, and will weigh about 40,000 pounds.

MAIN COLUMN. The shaft will be 6 feet 2 inches diameter (outside) at base, and 5 feet diameter (outside) at cap, and 17 feet high from bed-plate to cap. The capital will be 7 feet square and 2 feet 3 inches high.

BASES FOR BEAM PEDESTAL BLOCKS, will be 5 feet 3 inches by 2 feet 2 inches by 3 feet high.

MAIN BEAM PEDESTALS. Bases 3 feet 4 inches by 1 foot 9 inches by 1 foot 3 inches to centres, journals 1 foot 2 inches diameter by 2 feet long, brass box in bottom $2\frac{1}{2}$ inches thick, cast iron cap; both box and cap being lined with Babbit metal.

MAIN BEAM will be double, 28 feet between centres, 6 feet deep in middle, flange 10 inches by 3 inches, and middle rib 10 by 3 (flange and rib round edges), webb or plate $2\frac{1}{2}$ inches thick.

STEAM END—PARALLEL MOTION. Both cylinders will be connected to beams by a parallel motion formed with a main link, 5 feet long from centre to centre and 5 inches diameter in necks, and $5\frac{1}{2}$ inches diameter in middle, to large cylinder crosshead with boxes 6 inches in diameter by 7 inches long, and a pair of side links, 5 feet long from centre to centre and $3\frac{1}{4}$ inches diameter in neck and $3\frac{3}{4}$ inches

piston rod of large cylinder will be forked. The cross pin will be about 2 feet long. The crosshead for small cylinder will be 2 feet 4 inches long by 10 inches deep by $2\frac{3}{4}$ inches thick in middle, with journals $4\frac{1}{2}$ inches diameter by 5 inches long.

LOW PRESSURE CYLINDER, 57 inches diameter by 8 feet stroke, $1\frac{1}{4}$ inches thick; the piston will be 12 inches deep and the rod 5 inches diameter.

HIGH PRESSURE CYLINDER, 36 inches diameter by 5 feet $1\frac{5}{8}$ inches stroke, $1\frac{1}{4}$ inches thick; the piston will be 8 inches deep and the rod $4\frac{1}{2}$ inches diameter.

AIR PUMP CONNECTION. The rod will be 16 feet long by $3\frac{3}{4}$ inches diameter at neck and $4\frac{1}{2}$ inches diameter in middle; journals $3\frac{1}{2}$ inches diameter by $4\frac{1}{2}$ inches long.

AIR PUMP, 25 inches diameter by 3 feet stroke, brass lined, rod $3\frac{1}{2}$ inches diameter and brass cased, brass buckets and seats for the foot and delivery valves.

AIR PRESSURE FORCE PUMP AND FEED WATER FORCE PUMP will each be 3 inches diameter by 3 feet stroke.

MAIN CONNECTING ROD will be 24 feet 5 inches long by $5\frac{1}{2}$ inches diameter in neck and 12 inches by 6 inches in middle, journal 7 inches diameter by $8\frac{1}{2}$ inches long.

CRANK will be of wrought iron, finished bright.

CRANK SHAFT will be of wrought iron, at least 10 feet 6 inches long by 17 inches diameter; journal 16 inches diameter by 2 feet 3 inches long.

CRANK SHAFT PEDESTALS, base 3 feet 9 inches by 1 foot 9 inches by 1 foot 3 inches to centre; journal 1 foot 4 inches diameter by 2 feet 3 inches long; brass box in bottom $2\frac{1}{2}$ inches thick, cast iron cap; both box and cap being lined with Babbit's metal.

FLY WHEEL will be 25 feet diameter, and the rim will be of the required width and thickness to give a weight of about 65,000 pounds.

THE PUMP will be 36 inches diameter by 6 feet stroke, and $1\frac{3}{4}$ inches thick; the plunger will be $25\frac{45}{100}$ inches diameter; the bucket will be of brass, 20 inches deep on the side, with grooves to form a water packing; the flanges of the pump and air vessel will be $2\frac{3}{8}$ inches thick; the by-pass on the pump will be 4 inches diameter.

THE MAIN STEAM PIPE will be of wrought iron, welded, 8 inches diameter with wrought angle-iron flanges riveted and caulked, and cast iron flange elbows. The jacket supply steam pipe will be of

diameter in middle, with boxes $4\frac{1}{2}$ inches diameter by 5 inches long. The radius rods, anchor-blocks, parallel-rods, and back links will have corresponding dimensions as shown on drawing. The head of wrought iron, welded, 3 inches diameter with cast iron flange elbows. These pipes will be so arranged as to avoid any unfair strain on the joints by expansion and contraction. All steam pipes will be covered by porous covering, felt, and lagging of walnut with brass bands. The dimensions of other pipes, not given in detail, will be ample, and all connections conveniently and suitably made.

The Valves will be double beat, and for uniformity of size will each be seven inches diameter. The side pipes will be 10 inches internal diameter, and the exhaust will be 12 inches diameter between chest and condenser. The cam shaft will be $3\frac{1}{2}$ inches diameter (tubular). The cams will be $4\frac{1}{2}$ inches radius on outside. The cam rolls will be 6 inches diameter. The cam roll arms and the wiper on rockshaft will be 18 inches long. The rockshaft will be 3 inches diameter. The lifter rods will be $2\frac{1}{4}$ inches diameter. To other parts, not specified in detail, adequate proportions will be given.

All Flanges will be faced full width, and those of the steam cylinder and the junction of the column with the capital will be scraped joints. In the latter joint a copper band $\frac{1}{4}$ inch by $\frac{3}{4}$ inch will be caulked inside the joint.

All Bolts and Nuts will be turned up under heads and nut faces, and the surfaces on which they rest will be faced off. All nuts likely to be used frequently will be case hardened.

All Connecting Rods, gibs and keys and shafts will be of wrought iron and finished.

All Centres (including main beam centre), crank and wrist pins, and piston rods, will be of steel and finished.

All Glands and Stuffing Boxes will be bushed or made entirely of brass.

The Workmanship and Materials throughout will be equal to the best examples of English pumping engines.

The Steam Pistons will be fitted with Wheelock's patent steam packing.

Chemistry, Physics, Technology, etc.

A LECTURE ON LENSES.

By JOSEPH ZENTMAYER.

Ladies and Gentlemen.—Some months ago, being annoyed by a severe toothache, I went to a respected friend, a dentist. He examined my teeth, and said: "We will have to extract some of them." Seeing my nervousness, the doctor said: "It won't hurt you much, I will give you no more pain than necessary, I will treat you gently, if you please sit still." He pulled out three teeth *very* gently! I will not say that to hear a lecture on lenses is as bad as getting a tooth pulled, but I will say what the doctor said: "It wont hurt you much, I will not give you any more pain than necessary. I will treat you gently—and please sit still as long as you can bear it."

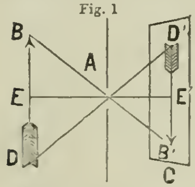
A lecture on lenses is a difficult one to make entertaining. It is especially so to me, as I am laboring under two disadvantages, the first of which, as you may have already noticed, is that I am not speaking in my mother tongue; and the second is, that I have never spoken before so large an audience. For over thirty years, the shop has been my domain. I hope you will make allowance for it.

Most of us recollect the splendidly illustrated lectures on light, by Prof. Henry Morton, and the well digested lectures on light and photography by Mr. Coleman Sellers before the Franklin Institute, and it remains for me only to recall to your mind some simple properties of light, relating to our subject, with which you are already familiar.

Light is propagated in a straight line. We cannot see around a corner. If a ray of direct sunlight passes through a small hole of any given shape into a darkened chamber, and we hold a screen near behind the aperture, we observe a bright image of the shape of the hole. If we increase the distance of the screen and the aperture, the image of the hole disappears in the penumbra, and the round image of the sun takes its place; and, if the hole is small enough, you

will see not only the image of the sun, but the image of all the external objects will appear likewise. This is one of the most interesting experiments, and its explanation is easy. Each point of the object

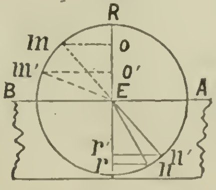
Fig. 1



B D (Fig. 1.) radiates light in every direction, light of the same color as it appears to our eye. From the point *B*, no light can reach the screen *C*, except through the small aperture *A* at *B'* ; but if the aperture is infinitely small, no other point of the object can send its rays to *B'*. The same is true for every other point, for *E* or *D* for instance; these can only send rays to their respective points *D'* and *E'*, and so on with the rest, and an inverted image, with all the natural colors of the object is produced on the screen. If we now enlarge the hole, different points of the object would reach the same place upon the screen ; the images of these points would overlap each other, and the image of the object would be indistinct. If the aperture is sufficiently enlarged, the image disappears, and the screen is illuminated homogeneously, taking only a tint of the most prominent colors of the objects. Therefore, the smaller the hole is, the sharper but fainter is the image. The size of the image depends upon the distance of the object from the hole, and also upon the distance of the screen from the hole. This primitive camera obscura is known by the name of pin-hole camera.

Light, we said, is propagated in a straight line ; but this is only true, when it continues in a medium of the same density, or if it enters a medium perpendicular or normal. But if a ray passes from one medium into another of different density obliquely, its direction is changed ; it is refracted. This property of light was known to the ancients about eighteen hundred years ago, but the discovery of the law of refraction was left to Willebrod Snell, professor of the University of Leyden, 1621. I will briefly state this very important discovery, which elevated optics to a positive science. If a ray of light, *R* (Fig. 2), falls perpendicular upon a plane surface of a piece of glass,

Fig. 2

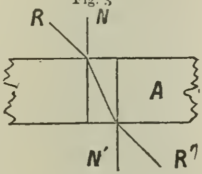


A B, it enters the glass without changing its course, in a straight line, *R D*, it only changes its velocity. But if a ray, *m*, strikes the surface at *E*, obliquely, it is refracted to *n*. A ray, *m'*, is refracted to *n'*. Now if we

erect perpendiculars from the points m and n, and also from the points m' and n', to the normal $R\ D$, and divide the length $o\ m$ by $n\ p$ and also divide $o'm'$ by $n'p'$, we will have in both cases the same quotient, or, as it is generally expressed: the sine of the angle of incidence divided by the sine of the angle of refraction is a constant, whatever the angle of incidence may be. This constant quotient is called the index of refraction. Different media have different indices of refraction; thus a diamond has a higher index of refraction than flint glass, and flint glass a higher one than crown glass.

Another important law of refraction may be mentioned, it is this: The incident and refracted ray and the normal are situated in the same plane.

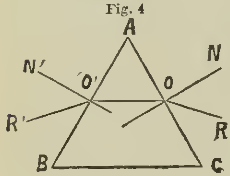
Fig. 3



If a ray of light falls on a parallel piece of glasss, A, (Fig. 3), perpendicularly, it will pass through it in a right line, because it is coincident with the normal. But if a ray, R, strikes the glass obliquely, it will be refracted toward the normal, N, and away from it when leaving it. As the normals n and n' are parallel, so must the incident and refracted ray be after leaving the glass.

Now let us see another case, where the two surfaces are not parallel, but form an angle with each other. Such a medium is called a prism.

Fig. 4

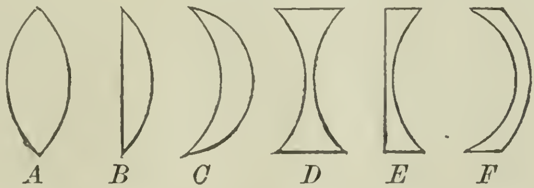


$R\ o$ (Fig. 4) is an incident ray; the ray is refracted towards the normal N, along $o\ o'$, and by leaving the prism it is again refracted, but this time from its normal N, as it passes from a denser to a rarer medium. Therefore, incident rays on a face of a prism are always refracted towards the base. We are now tolerably well prepared to see what a lens is.

A lens is a transparent medium, of which the two surfaces are either both curved, or the one is plane and other curved. If the curves are spherical, the lens is called a spherical lens, if the curve is parabolic it is a parabolic lens, etc. Lenses are divided into two classes, converging and diverging lenses. The converging lenses, which are thicker in the centre than at the margin, are: the double convex with both surfaces convex; the plano convex with one sur-

face plane and the other convex; and the convex concave (Meniscus) with one convex and one concave surface, but the convex of the shortest radius. This class of lenses, which may all be used as magnifying or burning glasses are called convex or positive glasses, and these only are, strictly speaking, lenses. The diverging lenses, which are thinner in the centre than at their margin, are: The double concave, with both surfaces concave; the plano concave, with one surface plane, the other concave; and the concave convex, with a concave and a convex surface, the concave having the shorter radius. These diverging lenses are called negative glasses. Fig. 5, exhibits the several lenses in the order we have named them; of which *A B C* are positive, and *D E F* negative glasses.

Fig. 5.



The general properties of lenses, which are of importance, are: first, the principal axis; second, the optical centre; third, the principal and conjugated foci; and fourth, the nodal points or conjugated centres. A straight line, drawn through the centres of curvature of the spherical surfaces of a lens, is the principal axis of the lens; if the one surface is plane, the axis passes through the centre of curvature of the spherical side, and is perpendicular to the plane surface. In all lenses the principal axis must go through the middle of the lens, that is, in the concave through the thinnest, and in the convex through the thickest part; otherwise, we have a prism with spherical surfaces, and not a lens.

Every lens possesses a point, situated in its principal axis, which is of great importance. Rays of light, passing through that point, will undergo equal opposite refraction, so that it will leave the lens parallel with the direction in which it entered. If we consider the lens without thickness, we simply say: rays passing through the optical centre of a lens, undergo no refraction. The optical centre can, readily, be found by drawing two radii, *A B* and *C D* (Fig. 6), from

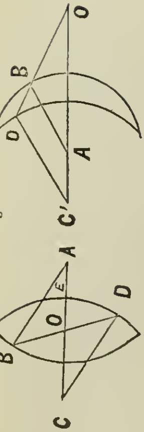
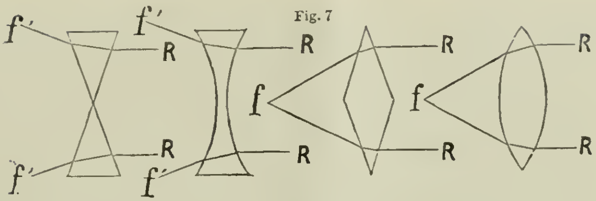


Fig. 6

the centres of curvature A and C' of its surface, parallel to each other, but oblique to the axis A C, then connect the two extremes B and D, and the line B D or its prolongation will cut the principal axis in O, the optical centre. If the lens is a double convex one of equal radii, the optical centre is the centre of the lens, or its centre of gravity. Fig. 6 is such a lens. Now suppose we change one curve into a shallower one, of longer radius, it is evident, that the optical centre is shifted towards the predominant, more curved side, and if we continue to make that side shallower, it will gradually move towards E, until the surface is converted into a plane, in which case the optical centre is coincident with the point where the axis cuts the curved surface E. This, we will see afterwards, is an important point. But let us go on in the same way, still reducing that surface by making it a concave or negative one; it is clear that the optical centre still marches on, moving out of the lens, and if we go on so far as to make the negative curve equal to the positive one, then the optical centre would be in infinity, and if we disregard the thickness, we have no lens, but a non-optical glass like a watch glass. All straight lines, passing through the optical centre of a lens are called secondary axes. The next and most important of the general properties of a lens is their principal focus and the conjugated foci. If we hold a convex lens towards the sun, and a sheet of paper at a certain distance behind it, we observe a bright little circle, in which the sunlight, falling upon the lens, is collected; the point where the circle is smallest, and, therefore, most intensely illuminated, is called the principal focus; that is, the focus for parallel rays.

If we have to calculate the area of a circle, we are bound to look at the circle as a polygon of an infinite number of sides, and we will do well to take the lens as an infinite number of prisms, more so, as the infinitely small portion of the lens, struck by the ray, may be taken for a tangent plane. Thus a converging lens may be considered as prisms united at their bases, and a diverging lens of prisms united at their apices. As we already know that prisms refract parallel rays towards the base, it is easily seen why converging lenses refract the rays R R (Fig. 7) to f, and that diverging lenses diverge the rays R R to f'.

Fig. 7



The distance of the focus from the lens depends, 1st, upon the curvature; 2d, upon the refracting power of the material; and 3d, upon the thickness of the lens.

Not to make the matter unnecessarily complicated, we will take the supposition that our lenses have an extremely small, or no thickness at all. For common glass of an index of refraction of 1·5, calculation shows that a plano convex lens has a focal length of the diameter of the sphere of which the lens is a part. A double convex lens of equal radii has its focus half that distance, or equal to the radius of the surfaces. If the double convex lens of equal radii, say of 10 inches, is made of the following substances, the thickness neglected, the foci would be,

For common	glass, index of	ref.	1·5	= focus	10	inches.
" flint	"	"	1·6	= "	8·33	"
" diamond,	"	"	2·439	= "	3·48	"

We see that the diamond lens of the same radius has a focal length of little over ⅓ of the crown glass lens.

We have now seen, that luminous rays from a point, infinitely distant, are collected to a single point in the axis, the principal focus. But let us suppose we move the luminous point towards the lens, to make the rays perceptibly converging; then, the lens, which was strong enough to bring parallel rays to the point, where the principal focus is situated, is not strong enough to bring these diverging rays to the same point, but they will cross the axis at a point farther removed from the lens; and as the radiating, luminous point is moved nearer to the lens, the farther off from the lens they will cross the axis; by moving still on, we came to a point, where the radiating point and the point where the rays cross the axis on the opposite side, are equally distant from the lens. In this case, the radiating point and the rays where they cross the axis are nearly four times the distance of the principal focus apart. For ordinary purposes, this affords a ready means to determine the principal focus of a lens. But let us move on still nearer to the lens, and the focus on the other

side will continue to move farther away, until we reach the principal focus this side; then the rays will emerge parallel on the other side. By over-stepping that point, the rays will emerge diverging. These variable distances of the luminous point and the focus on the other side, are called the conjugated foci. There remains to be mentioned another important general property of lenses, the nodal points, or, as they are sometimes called, the centres of admission and emission.

M is a double convex lens of equal radii, *o* is its optical centre. Any ray passing through the optical centre, as *R R*, emerges on the other side parallel to its first direction, *R′R′*, as explained before. If we now prolong *R* and *R* in their first direction, they will meet at a point *P*, the one nodal point, or the centre of admission, and if the emerging rays are also prolonged, they will converge to a point *P′*, the other nodal point, or the centre of emission. We recollect that in the pin-hole camera the size of the image compared with that of the object is exactly in the same proportion as the distance of the screen to the hole is to the distance of the object from the hole. These distances represent the two conjugated foci, as there is no deviation of the rays from a straight line, and the two triangles, which are to be compared, meet with their apices. But if we have a bi-convex lens (Fig. 9) and *A B* an object, *CD* its image, it is clear that the conjugated foci are to be measured from the nodal points *P* and *P*, and the two conjugated foci are *F P* and *F P*, showing how erroneous it is to measure the foci either from the surface of the lens, or from the optical centre. In a Meniscus, the one nodal point is situated outside of the lens, and the other one inside of the lens. But in a plano convex lens the optical centre, as well as the nodal point, is situated where the principal axis crosses the curved side. The plano convex lens is therefore the only lens of which the focal length can be measured directly. If the plane side is placed towards a very distant object, the distance of the curved side to the image is the principal focus.

Fig. 8

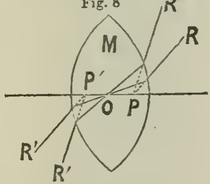
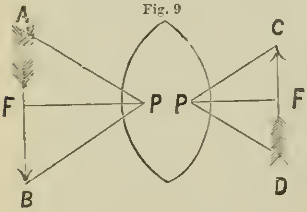


Fig. 9



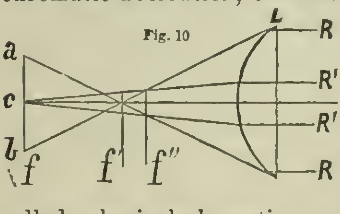
It is often necessary to know the focal length of a lens or a combination of lenses, especially in photography; but if no plano convex lens of known focal length is at hand, for the purpose of comparing the size of the image, the following way may be adopted: first, focus

the lens for a very distant object, on a screen, and mark the position of the screen. Do not move the lens but place a bright object, about twice the focus of the lens, in front of it as near as you can suppose; now move the screen about the same distance from the lens, as the object was placed, and focus thereupon. If you find the object and image not of exactly the same size, move object and screen accordingly, and focus sharp, until the object and image are precisely of the same size; mark the position of the screen again, and the distance of the first and second mark is the focal length of the lens, or the equivalent lens of a combination of lenses.

We are now acquainted with the most important properties of a lens, and it remains only to be said, that all combinations of lenses have precisely the same general properties as single lenses.

We come now to a somewhat more complicated and difficult part of the subject, the aberrations of lenses, and the modes of their correction. So far we have supposed the lens as very small, in relation to its focal length, and that, with such a lens, all rays coming from one point, are refracted by the lens in one point again; but in practical optics such is not the case, as lenses of very large aperture are often required in modern optical instruments, and the rays coming from one point are no longer collected in one point, and this optical defect occasions the different aberrations. For over a century the correction of these aberrations employed our most eminent mathematicians, as Euler, Fraunhofer, Herschel, Fresnel, Littrow, Gauss, Airy, Petzval, and others.

The most important of these aberrations are: spherical aberration, chromatic aberration, curvature of field, distortion and astigmation.



The marginal parallel rays R R (Fig. 10), passing through a convex lens, L, cross the axis at f', nearer to the lens, than the more central ones $R'R'$, which cross at f. This is a result of the spherical surface of the lens, and is called spherical aberration.

If we present a convex short focus lens to solar rays and produce a sharp image of the sun on a piece of white paper, we will find that the image at f, which is the one made by the central rays (and therefore is the sharpest), is surrounded by a halo, a b, which is what we call the lateral spherical aberration. This halo is, as you see, pro-

duced by the shorter marginal rays, $R\ R$, after crossing the axis, diverging, and is also called the circle of aberration. $f'f$, the distance of the difference of the central and marginal rays, constitutes the longitudinal aberration. The least spherical aberration is where the two cones intersect each other between f' and f. This aberration is called positive.

If converging rays $R\ R$ and $R'R'$ (Fig. 11), which we suppose would be collected in the point o, fall on a concave lens, the marginal rays $R\ R$ are refracted stronger than the more central ones $R'R'$, consequently $R\ R$ will cross the axis farther from the lens, at f', than the more central ones, $R'R'$, which cross the axis at f. In this case the spherical aberration is of the opposite character, and is called negative aberration. It is evident from the foregoing that spherical aberration varies with the aperture of the lens, and the material of which the lens is made. Therefore, the larger a lens is in proportion to its focal length, the greater is its spherical aberration;—a lens of an aperture of, say 1-50th of its focal length has no perceptible spherical aberration. The longitudinal spherical aberration increases as the square of the diameter of its aperture, and inversely, as its focal length, while the lateral aberration increases as the cube of its aperture, and inversely, as the square of its focal length.

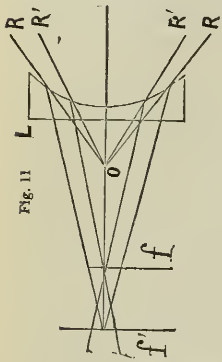


Fig. 11

Thus, if we have two lenses of the same curvature, made of the same material, but the one of twice the aperture of the other, the longitudinal aberration of the larger one is four times as great, and the lateral or circle of aberration is eight times as great as that of the smaller one.

If two lenses have the same aperture, but the focal length of the one is twice as long as that of the other, the longer one has only one-half the longitudinal, and one-fourth the lateral aberration. As a lens made of a denser medium, say of heavy flint glass or diamond, requires, for the same focal length, a longer radius of curvature than one made of crown glass, it follows, that its spherical aberration is less.

The single lens of ordinary glass, having an index of refraction of 1·5, has the form of least spherical aberration when it is a crossed

or convex lens with the surfaces of different radii, the proportions of the radii depending on the index of refraction of the material of which the lens is made. For ordinary glass, index 1·5, the radii are as 1 to 6, the shortest curve towards parallel rays. The best form for a lens made of flint glass, index 1·6, is the plano convex, and for diamond, is a Meniscus, of which the convex radius is to the concave as 2 to 5, for radii of curvature.

We see that in lenses of wide apertures the spherical aberration may be considerable enough to interfere with the sharpness of the image, especially if, as in a telescope and microscope, the image with all its errors is magnified by an eye-piece. Let us now see what means we have to reduce, correct, or destroy the spherical aberration. The most simple way is by the use of a diaphragm. A diaphragm is a non-transparent plate, commonly made of metal, perforated in centre. *A B* is such a diaphragm; *c d*, the aperture of it. If this diaphragm is placed in contact with the lens, it is nearly equal to reducing the lens to the size of the aperture of the diaphragm, and as we have seen before, the spherical aberration is considerably reduced, but the light also. If the loss of light is of little consequence, this mode of reducing spherical aberration may be adopted with advantage. Another way of reducing the spherical aberration is by adopting for a given aperture and focal length two or more lenses of the same aperture, and the same equivalent focus of the single lens. We have seen before, that two lenses of the same aperture, but their focal length, as 1 to 2 to each other, the longer one has only one-fourth of the spherical aberration of the shorter one. Lens *M* (Fig. 13) has its focus at *f*. The lenses *L* and *N* are of the same aperture as *M*, but each has twice the focal length of the lens *M*; therefore, each has only one-fourth the spherical aberration of *M*, but *L* and *N* together have the same focal length as *M*, and as their apertures are alike, the combination *L N* has only one-half the lateral spherical aberration of the lens *M*. But by this mode of correcting, it is not possible to destroy the spherical aberration completely, although it is stated in some works on optics, that a combination of two convergent lenses was calculated by Sir John Herschel, and said to be free

Fig. 12

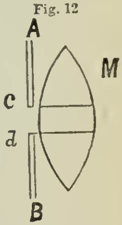
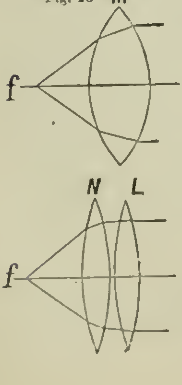


Fig. 13



of spherical aberration. This, however, is a mistake, which Herschel himself has rectified in his memoirs.

We now come to the most important method of correcting spherical aberration, that is, by a second lens of opposite character. Suppose we want to correct the spherical aberration of the positive lens, *L*, (Fig. 14) along its axis. *ff′* is the longitudinal spherical aberration of the rays *A B*, parallel to the axis *A*, at the margin of the lens, and *B* near the centre of the lens *L*. If we combine this lens with a convergent negative lens, *M*, it is not difficult to see, by what we learned before, that the lens *M* has very little power to change the direction of the ray *b f′* and bring it, say to *F*, but it will greatly change the course of *A f*, so as to bring it also to *F*, since the prismatic form is greater at the margin than at the centre. Of course, the form of the lens must be suited to the material of which it is made; for our present purpose, both of the lenses may be made of the same glass, but it is much better if the lens *M* is made of a denser glass, as we soon shall see, that the same lens may be used to correct the chromatic aberration also. By this method the spherical aberration can not only be corrected, but the marginal rays can be made to cross the axis farther from the lens than the central ones; in this case the lens is called over-corrected, while if not enough corrected, it is called under-corrected. So far we have considered the aberration of rays parallel with the axis. But magic lanterns, photographic and microscopic lenses include angles from 40° to 175°, and the foregoing is only applicable to a narrow angle near the centre of the lens. If a lens, corrected parallel to its axis for spherical aberration, is struck obliquely by parallel rays, the longitudinal aberration is different for two diameters, and is greatest in the plane, laid through the axis of the lens and the radiating point; therefore, the circle of aberration becomes the more elongated, as the more obliquely and marginally the light strikes the lens, until it terminates in a point at their extreme margin, which is known as the coma.

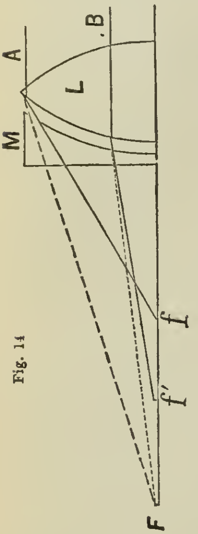
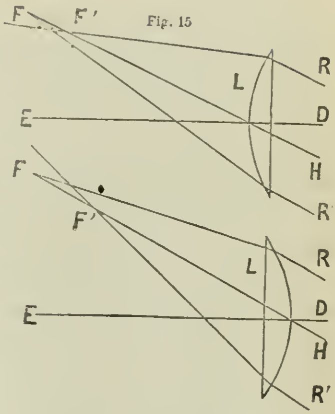


Fig. 14

L is a plano convex lens; *H F*, an axis through the optical centre, making a considerable angle with the axis *D E*. *R* and *R′* are parallel



marginal rays. The ray R will cut the axis at F', and R' farther off at F, and therefore the image of a luminous point is no more a point, but appears elongated, and in the extreme has the shape of a coma, which in this case is directed downwards. If we reverse the lens, as in the next figure, so that the incident rays fall on the convex side, the coma is directed outwards. We see, we have here, by reversing the lens, opposite comas; and such lenses of opposite character properly combined, at the right distance, and furthermore, by the use of a diaphragm at the proper place, the spherical aberration for oblique rays, can be reduced to a small amount.

(To be continued.)

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Continued from Vol. ci, page 270.]

The author remarks in a note that the number 21 for ice and salt signifies the permanent temperature below 0°, which is observed till the whole mixture is melted. The correct number in relation to the other freezing mixtures would be 81°, *i. e.*, the sum of the latent heat of ice 79°, and the dissolving temperature of salt, 2·5°. This temperature would be actually observed if a concentrated solution of salt had no freezing point, when the entire mass of ice and salt would melt at once.

Mixtures of salts yield a far greater decrease of temperature than the salts singly, as they dissolve together in far less water. One part sal-ammoniac dissolves in 3 parts of water and produces a fall of temperature of 19°. Saltpetre dissolves in 6 parts of water and

* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

lowers the temperature 11°. Compare with these the fourth and fifth mixture in the foregoing table. The fifth is also especially to be noticed in comparison with the fourth.

The three last columns of the table show the consumption of materials and the cost (retail and wholesale) for 120 heat units, which suffices, in case of the salt and ice mixture, for the conversion of 1 kilo. of water into ice. The other mixtures only convert about ½ kilo. with the same consumption.

The ice and salt mixture, which is added for comparison, will be seen to be much more efficient and much cheaper than all mixtures, if it is intended to use the materials only once. The second mixture, Glauber's salt and hydrochloric acid, cannot be re-used, as likewise the last mixture in the table. These two are still relatively cheap. The mixture, which, by evaporating the solution of the saline residue, can easily be restored to its original state (nitrate of ammonia and sal-ammoniac), requires such a heavy outlay that it would be out of the question if used only once. It was used in an apparatus by S. Charles, which first became known at the Paris Exhibition of 1867. This consisted of a small wooden cask with a perforated lid. The inner vessel containing the articles to be frozen was made of tin, and was fitted with a screw thread so that when caused to revolve it effectively mixed the salts and the water. Another modification, by Toselli and Co., of Paris, is known as the glaciere italienne roulante.* It consists of a tall tin capsule, in which a conical tin tube is suspended. A good cover connects both vessels, and the internal tube in which are put the materials for the ice cream is also stoppered separately. The freezing mixture occupies the annular space around the tube. When charged, the whole apparatus is wrapped up in cloth and rolled up and down upon a table. In efficiency both forms of apparatus are nearly equal, but the first mentioned is more convenient. Neither has come extensively into use, at least not in places where ice is to be procured. It is necessary to work upon large quantities in obtaining trifling results. 4 kilos. of mixture yield scarcely 1 kilo. of ice cream of less firmness than that prepared with ice and salt, or a little more than ½ kilo. in summer. Where cold spring water is not to be had, or where no cold cellar exists, the result is altogether doubtful without repeating the operation twice over, the first process being the preparation of cold water, which is too tedious.

* *Bad. Gew.*, 1868, 106. *Wagn. Jahresber.*, 1867, 538, and 1868, 605.

The evaporation of the saline solution in order to recover the salt, is a task such as does not otherwise occur in the kitchen, and requires some care in its performance. The total of the process is not adapted for domestic arrangements, even though the expense of restoring the salts be insignificant.

We have now to examine in how far the solution of salts is available for the production of ice on a commercial scale. This question can be arithmetically answered by means of the figures given in the table. To prepare 1 kilo. of ice from water at the mean temperature of 12° C., not much less than 120 heat units will be consumed, if we take losses into consideration. This amount is, indeed, yielded by the mixture of nitrate of ammonia and sal-ammoniac; but little more than the half of this falls below 0° C., since the substances used in the most favorable case will have this initial temperature. The cold still contained in the spent mixture, when no longer applicable for freezing, may, indeed, be transferred to the water used in a fresh mixture, and thus the total cold of solution below 0° may be conceivably utilized, losses being neglected. We require, therefore, 3 kilos. of water for 1 kilo. of ice, and in the regeneration of the materials these 3 kilos. of water must be evaporated by artificial heat. The effect of 1 kilo. of coal burnt under the evaporating pan amounts to little more than 6 kilos. of steam. Consequently 1 kilo. of coal yields little more than 2 kilos. of ice, overlooking, too, the mechanical power required. This result is very unfavorable, since other ice machines produce a better effect—the ammonia apparatus four to five times greater. Hence no arrangement for the manufacture of ice on the large scale has been constructed on this principle, although it would have a great advantage in simplicity of structure, requiring merely open vessels. Nor can we expect that the circumstances will ever appear more favorable, except salts are discovered, which, during their solution, produce a fall of temperature several times greater than that of the known mixtures. But this is improbable, since all known salts have been examined in this respect. If common salt were so costly a body that its recovery were desirable, not more salt than would serve for 4 kilos. of ice could be recovered by the consumption of 1 kilo. of coal in evaporating the spent mixture.

We may finally mention that in 1869, Rüdorff* examined the fall of temperature to be obtained by the solution of single salts. His

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* Rüdorff, *Ber. Chem. Ges.*, ii, 68. *Dingl. Pol. J.*, cxciv, 57. *Wagn. Jahresber.*, 1869, 508.

table of results contains 20 salts, among which we call attention to two not yet mentioned, as they produce the lowest temperature of any single salt: the sulphocyanides of ammonium and of potassium. 105 parts of the former dissolved in 100 parts of water produce a fall of 31·2°; 130 parts of the latter in 100 parts water lower the temperature 34·5°.

II. *Cold from Spontaneous Evaporation.*

Liquids capable of forming vapors require, as is well known, for their transformation into the gaseous or aeriform state, considerable quantities of heat, which are necessary to maintain them in that condition. The heat of evaporation is not indicated by the thermometer, and is therefore often spoken of as combined heat in contra-distinction from the so-called free heat which acts upon the thermometer and determines temperature. The combined heat of different liquids varies greatly; that of water, *e. g.*, at a temperature of evaporation = 34°, amounting to 58·3 heat units, whilst that of an equal weight of ether evaporating at the same temperature is only 90.

In the process of evaporation liquids are compelled to draw their supply of heat for evaporation in the first place from their own store of free heat. In consequence the temperature sinks. As, however, heat is conveyed from without to every substance whose temperature is lower than that of its surroundings, and as this influx is the more rapid, the greater the difference of temperature, the cooling process is not without its limits. A state of equilibrium is attained as soon as, at a certain reduction of temperature, the loss of free heat caused by continued evaporation is compensated by the access of heat from without.

The depth of the lowest temperature of an evaporating liquid is more or less dependent on external circumstances. This point is, however, in all cases reached the more readily because as the temperature of evaporation falls, the tension of the vapor, and at the same time its density and its quantity, decrease. The volume, *e. g.*, of 1 cubic meter, which at 34°, can be filled with 37·25 grms. of saturated watery vapor, admits, at 0°, only 4·76 grms., and at — 10°, only 2·29 grms. Hence, it is perfectly plain that at — 10°, circumstances being otherwise unaltered, evaporation proceeds much more slowly, and consequently the accession of heat from without must have a greater effect than at 34°.

The case is similar with other liquids, but so, in general terms, that those evaporate most rapidly which, at a given temperature of evaporation, possess the greatest maximum tension, or, what amounts to the same thing, those whose boiling point lies lowest. Thus, if ether evaporates spontaneously, the volume of 1 cubic meter contains at 34°, 3750 grms.; at 0°, 1515 grms.; and even at —10°, 654 grms. of vapor; whilst at this temperature water yields only 2·29 grms. The much lower latent heat of the vapor of ether is, as we see, amply compensated by the far greater weight of the mass that evaporates under equal conditions. Thus the strong cooling power of evaporating ether is easily intelligible.

Still more striking in this respect are liquid sulphurous acid and liquid ammonia, whose boiling points are respectively — 10° and — 33°.

The intensity of the cooling of an evaporating liquid is greatly augmented by cutting off, as far as possible, the accession of heat from without. This is effected, of course, by the use of coverings which conduct badly. On the other hand an attempt is made to remove influences which interfere with the speed of evaporation. An essential point is removal of the external atmospheric pressure, since the air opposes a mechanical hindrance, not, indeed, to the formation of the vapor rising from any liquid, but to its rapid dispersal. Hence a given space, for whose perfect repletion with saturated vapor several minutes would not suffice, is almost instantaneously saturated if the air be withdrawn.

For the removal of the air a good air pump is in most cases employed. The air pump alone as a promoter of evaporation would, however, in general, prove insufficient, since its action is not powerful enough to remove the vapors with the same speed as they are produced in a space free from air. But the evaporation is completely interrupted as soon as the given space is filled with vapor of the same temperature at which the evaporation goes on. This purpose of a speedy removal of the vapors arising from an evaporating liquid is satisfactorily effected by their absorption ; thus the vapor of water is removed by means of concentrated sulphuric acid.

For the generation of cold by evaporation, liquids are most suitable which require a technical preparation and possess a considerable value. In the manufacture of ice on the large scale it is therefore needful to restore the escaping vapors to their original condition, *i. e.*,

liquids capable of re-evaporation so that a given quantity of material may serve again and again, circulating continually. This restoration can be effected by two processes, different in form and action, of which the ether machine and the ammonia machine are respectively almost the sole existing representatives.

The ether machine is arranged as follows :—A double action air pump, worked by some especial source of power (generally a steam engine), draws incessantly the vapor of ether out of a vessel filled with liquid ether (ice generator or evaporation receiver). By the return of the piston the vapor is compressed and driven into a worm cooled by water. As the vapor which has been heated by compression cools, it condenses to a liquid which is collected in a suitable vessel, whence it is driven by the pressure of the condensed vapor back into the evaporation receiver, where it recommences its function.

The principle of the ether machine was patented in England by Jac. Perkins, of London, as early as 1834. His apparatus contains all the parts requisite for continuous action—evaporation receiver, air pump, and worm condenser. The first mentioned part, according to the drawings, consists of a vessel like a boiler, formed of two segments of a sphere and surrounded with water. This arrangement is not very suitable, possibly for the reason that nothing further has been heard of the devolopment of the apparatus. Or, possibly the time was not yet come for the utilization of the principle, the demand for ice being not important enough to render it a remunerative business.

The next patent for an ether ice machine was taken out in 1856, by John Harrison, of Geelong, in Victoria. In September, 1857, he obtained a patent for improvements, according to which latter the machine is arranged, as follows :—The evaporator has the form of a horizontal tubular boiler, with numerous narrow tubes. Through tubes a concentrated solution of common salt which is pumped up at the top, streams down in a zigzag direction, the tubes being divided in three sets from above, downwards. The ethereal liquid streams out of the condenser into the boiler outside the tubes. The solution of common salt passes from the boiler into a long tank, in which are suspended vessels of the water to be frozen (ice boxes), passes through it, and is pumped up again into the boiler. The arrangement is perfectly rational. Harrison states in his specification that he can, by means of his machine, produce a temperature of —29° ; but from an economical point of view he prefers —2° to —5°. The process of

freezing is then slower, but the expenditure of power is much less, and the ice is transparent like natural ice. At the end of the year 1859, Lawrence established works at Liverpool for the production of artificial ice, and sold it at one halfpenny per lb. Dullo* and Grünberg† have described the process, the latter with illustrations. From 40 to 60 cwts. of ice were prepared daily by means of a steam engine of 15 horse power. In 1860, Laboulay‡ described an ether ice machine by F. Carré, of Paris. In it the ether acted directly upon the water to be frozen.§ It was soon abandoned by Carré after he had succeeded in carrying out the ammonia machine, which is far more efficacious. In March, 1862, Dr. Siebe, of Lambeth, obtained an English patent for an improved ice machine. The general arrangement is the same as Harrison's. The boiler, instead of being horizontal, is vertical. There are also changes in the air pump and the cooler, which do not affect the principle. The ice boxes are so arranged that when the first one, which is exposed to the influx of the cold liquid, is frozen and taken out, the entire series slides forwards, and the new box filled with fresh water comes in last. From this date we find Siebe's name alone connected with the machine in question, which, however, is still spoken of as Harrison's principle. Siebe's machine figured at the London Exhibition of 1862.

Siebe's machine appeared at the London Exhibition of 1862. Schmidt|| published an illustrated description of the machine exhibited, remarking that another machine in the possession of the patentee, worked by a 24 horse power engine, produced 5 tons of ice in 24 hours, which, under the most favorable circumstances, may be regarded as 4 kilos. ice per kilo. coal consumed. In this machine the evaporator is like a boiler with horizontal tubes. It is stated that** the cost of producing the ice amounted to one and a half marks (about 1s. 6d.) per cwt. A further account of Siebe's machine is found in *Engineering* for 1868, No. 483.††

According to this journal such a machine was in use in Truman

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* Dullo, *Dingl. Journ.*, clviii, 115.

† Grünberg, *Pol., Centralbl.*, 1863, 656.

‡ Laboulay, *Bull. Soc. d'Enc.*, 1860, 129.

§ *Dingl. Pol. Journ.*, clviii, 109.

|| Schmidt, *Dingl. Pol. Journ.*, clxviii, 434.

** *Dingl. Pol. Journ.*, clxvii, 397.

†† *Dingl. Pol. Journ.*, cxci, 189.

and Hanbury's brewery, in London, yielding 6 tons of ice per twenty-four hours, and worked by a high pressure engine of 15 horse power. 1 cwt. of coal produced $4\frac{1}{2}$ cwts. of ice. The solution of salt is said to have a temperature of $-8°$ to $-12°$. In 1870, appeared a final description of Siebe's machine.* A new and very compact little apparatus is mentioned, driven by a 1 horse power engine, consuming 5 to 6 lbs. of coal per hour, and yielding 12·5 to 15 kilos. of ice hourly or 5 kilos. of ice to 1 of coal.

No intelligence has been obtained concerning ether machines from other countries and by other makers. It has never, to our knowledge, been brought into use in Germany. At the Vienna Exhibition this principle was represented by one machine by Siebe and Gorman, of London.

Ether is a liquid which, under ordinary pressure, boils at 35° C.; under other circumstances the relation between temperature and pressure is as follows:—

Temperature,	—20°	0°	+20°	40°	90°	120° C.
Pressure,	0·09	0·24	0·6	1·2	5	10 atmos.

If allowed to evaporate much below the freezing point of water the tension of the vapor is very low, perhaps only one-tenth of an atmosphere. Hence the external air exerts a great and permanent pressure upon the evaporator, and upon the air pump which draws out the vapor. The joints and fastenings must therefore be made with extreme care, lest a trace of air should enter, which would have the most pernicious influence on the working of the machine, and especially on the speed of evaporation. On compressing the vapors, the tension rises to several atmospheres, and a rise of temperature occurs, amounting certainly to more than 60°. If cooled at this pressure, the vapor recondenses to a liquid. More accurate statements as to relative pressure and temperature of the vapor of ether cannot be found. The basis for the calculation of the theoretical duty of the machine is the same as that of the air machine to be described below, for which the requisite data are furnished and to which we may refer. From the known magnitude of 90 heat units (the latent heat of the vapor of ether), it is possible to calculate how much ether theoretically, must be evaporated to yield a given weight of ice.

Substitution of Methylic Ether for Ethylic Ether.—Methylic ether is formed by the action of sulphuric acid upon methylic alcohol or

* *Prakt. Mech. J.*, 1870, 251.

wood spirit, a homologue of the ordinary ether produced by the action of sulphuric acid upon spirits of wine. and distinguished by its far greater volatility. Methylic ether is gaseous at ordinary temperature and pressure, and can be condensed to a liquid only by great pressure or by cold. The liquid, at the pressure of one atmosphere, boils at — 21°. Tellier, of Paris, has used this ether as an agent for the production of cold in his ice machine, which is constructed exactly like that of Siebe.*

The difference in the effect can only be explained by the production of a far lower temperature. Within the entire machine also there is an excessive tension, so that the vapor seeks to escape at the joints, thus debarring the air from entering. The air pump also is of much smaller dimensions as it draws and compresses a far denser vapor, thus notably reducing the loss of power due to the friction of the piston. If, however, the work is carried on at greater differences of temperature than in the common ether machine, the engine must expend more power, as appears from the theory of the air machine. For equal temperatures of evaporation and condensation, the theoretical effect of the two machines is equal. Tellier keeps a sufficient quantity of methylic ether stored in cast iron vessels capable of bearing a pressure of 10 atmospheres. On opening a cock the gas streams out, the liquid is cooled, and if the vessel is set in water this soon becomes frozen. The ether is thus certainly lost. Occasionally this method may be found useful.

Other substances of low boiling points. may, like the above named ethers, be applied for producing a fall of temperature, but no different result can be expected from their theoretical action. Thus Van der Weyde, of New York, makes use of chymogen, a constituent of natural petroleum, evaporating between 0° and 16° C., of which, in the United States, a liter costs only 14 to 24 Pfennige (12 Pfennige = 1½d. English).† Liénard and Hugon, of Paris, are said to use sulphide of carbon.‡ An original proposal by Mort and Nicolle, which may be regarded as a combination of the above described system with the following, will be considered below.

Application of Carbonic Acid.—Carbonic acid has been repeatedly proposed as an agent for the production of cold. In 1867, a pro-

* *Engineering*, 1871, 179. *Dingl. Pol. Journ.*, cciii, 191. *Pol. Centralbl.*, 1872, 38.

† *Deutsche Industriez*, 1869, 339.

‡ Private communication.

visional protection for this principle was taken out in England, but the patent was never completed. *A priori* carbonic acid cannot be regarded as a very suitable means for effecting a fall of temperature. It has, indeed, in comparison with all other materials hitherto proposed (except air), the advantage of cheapness, and in contrast to the ethers, that of incombustibility, and therefore of freedom from danger. The pressure of the liquefied acid is, however, enormous, and hence the receivers require to be made very strong, and the connections occasion much difficulty. The temperature and tension of liquid carbonic acid show the following relations:

Temp.,	—60°	—30°	—15°	—5°	0°	+10°	+15°	+30° C.
	4·5	16	25	33	38	46	51	73

As the temperature at which the carbonic acid is condensed in the cooler cannot be lower than + 10° C., the tension is then 30 atmospheres, and even at — 30° C., a tension of 16 atmospheres would ensue.

At the Vienna Exhibition a peculiar attempt was shown to use carbonic acid as a means both for the production of power and of cold. The machine was constructed by L. Seyboth, of Vienna, and was contrived as follows:

The carbonic acid, generated from sulphuric acid and iron spar, was evolved in a closed receptacle at the pressure of 4 to 6 atmospheres.

(To be continued.)

THE THEORY OF THE "HOLTZ" ELECTRICAL MACHINE.

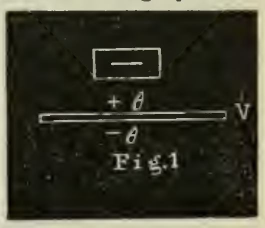
By D. S. Stroumbo, Professor at the University of Athens, Greece.*

1st. Much doubt still exists in the minds of those who have used or investigated the Holtz electrical machine as to the proper explanation of the development of electricity by its means, and the writer now proposes to exhibit the theory of its operation and explain away this uncertainty.

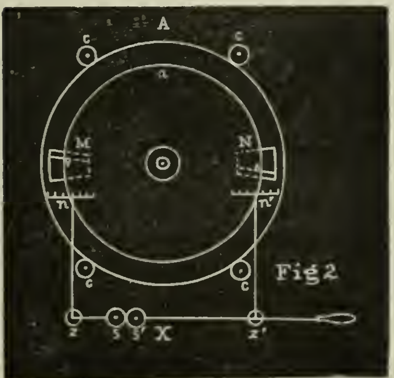
2d. Of course this explanation must be made to be in accordance with experiments and with known theoretical principles; and these have already established the belief that the rapidity of induction of

* From *Les Mondes*, a weekly review of the sciences and their application to arts and industries.—Paris, Feb. 3, 1876.

electricity in a body bears a direct relation to its conductivity; so that it will be admitted that glass and similar bodies of imperfect conducting power will become electrical by induction more slowly than other bodies in which the capability to transmit an electric current at higher velocity exists. It follows that if a large plate or sheet of glass, V, (Fig. 1), is turned before the source of electricity, scarcely any development of the two electric currents upon the opposite face* of the glass will become apparent, especially if the source of electricity is a feeble one; besides, the two electricities oppose each other, $+\theta$ and $-\theta$, and are equal. They attract each other and destroy themselves, after having passed over the two faces of the plate of glass.



3d. Imagine, however, that the observer places himself at X, (Fig. 2), having before him two circular plates of glass, *A* and *a*, placed vertically about one-eighth of an inch apart, the radius of *A* exceeding that of *a* one-fifth. The plate *A*, with a hole in its centre, is held fixed and vertical by four small caoutchouc rollers, *c*, and before it is the plate *a*, which is carried on an axis, so that it can be turned by a crank or otherwise at the desired velocity of fifteen turns per second. Upon the fixed plate, *A*, are perforated two openings, or windows, close to the periphery or edge, in the line of the horizontal diameter, and each of these openings (on the upper edge of one and lower edge of the other) has a strip of paper attached to the glass. This strip being about 1¾ to 2 inches in width (the plate *A* in such case being supposed to be about 2½ to 3 feet in diameter); these are the armatures, and attached to the middle of the length of each of them, is a point of paper directed across the centre of the openings.

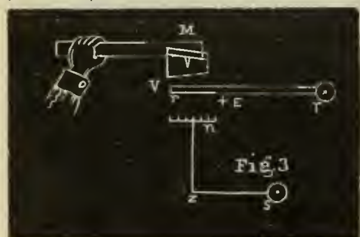


* The front surface (of a plate of glass) rotated before a source of electricity, is charged feebly positively, while the back surface will become feebly negative.—"*Riess Poggendorff Annalen*," cxxxi, p. 215.

On the same level as the armatures, and on the opposite end of the movable plate *a*, are placed two combs or toothed plates of metal *n* and *n′*, which are joined separately by horizontal wires to the balls *s* and *s′*. The ball *s* is fixed, and the ball *s′* can be brought up to or removed from it by means of the rod *s′z′*, which has a handle of caoutchouc. The metallic conductors *n z s* and *n′ z′ s′* are isolated and carried on glass feet.

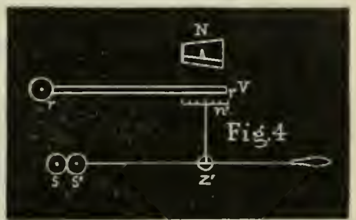
4th. The machine is put into action by making the contact of the two balls *s* and *s′*, and rotating by means of its crank, the movable plate *a* in the direction opposite to the points of paper, having at the same time applied for a few moments against the armature *M*, a strip of hard caoutchouc, in which an electric charge has been already formed by rubbing it with a hair skin. If the surrounding air at the time is dry, it will not be long (after removing the charging plate) before a continuous rustling sound will be heard, which proceeds from the reunion of the two electricities between *s* and *s′*, and separating them gradually, sparks will appear, sometimes seven inches or more in length.

5th. According to Reiss, the development of the two electricities of this machine is explained as follows: The strip of caoutchouc gives up to the armature *M*, negative electricity, (Fig. 3). This electricity is negative then by induction upon the plate of glass *a*, and upon the conductor *n z s* at the same time, and there is then upon the opposite faces of the glass plate V, (Fig. 1), the two very feeble currents, $+\theta$ and $-\theta$, which, as they have mutually destroyed each other, could therefore be properly assumed to have possessed no value in this inquiry.



A similar result from the negative electricity of the armature *M* is produced upon the conductor *n z s* (excited by induction), giving to the ball *s*, the negative electricity $-E$, the positive electricity $+E$ having escaped by the points *n* upon the face *r r* of the plate (Fig. 2 and Fig. 3) which carry it away during the movement of the plate.

6th. After a half rotation of the movable plate, the face *r r*, electrified positively, $+E$, is brought in front of the point *n′* of the conductor *n′ z′ s′*, and the armature *N* placed upon the opposite side,



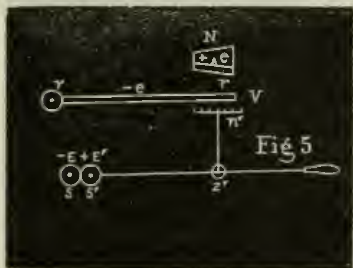
(Fig. 4). The electric current $+E$ yet continues upon the face $r\ r$ of the plate, where it will be observed.

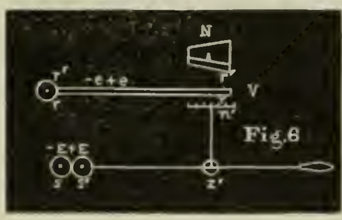
1st. That the ball s' receives negative electricity.

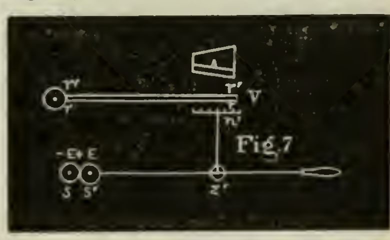
2d. That the face $r\,r$, of the plate, having lost the negative electricity, with which it returns, after another half revolution, to its first position before the armature M.

7th. This positive electricity, $+E$, producing its inductive effect within a very short time, and simultaneously upon the armature N, and upon the conductor $n'\ z'\ s'$, it is necessary for the conception of the effects to examine them successively.

The positive electricity, $+E$, changes the electrical condition of the armature N, repelling the positive electricity $+e$, (Fig. 5), and attracting the negative electricity, $-e$, which is escaping by the point of paper attached to the face $r'\ r'$ of the plate. At the same time the positive electricity, $+E'$, changes the electrical condition of the points of n' and of the conductor $n'\ z'\ s'$, repelling the positive electricity, $+E'$, upon the bal s, where it is collected by the contrary electricity e' of the ball s,* and attracts the negative electricity, $-E$, which, having escaped by the points n', will have very nearly neutralized the negative electricity $-e$, which existed on the face $r'\ r'$ of the plate (Fig. 6 and Fig. 7). Thus before the positive



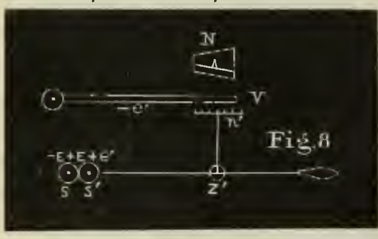




electricity, $+e$, of the armature N escapes, and during the brief space of time in which it is retained upon the armature N, it will

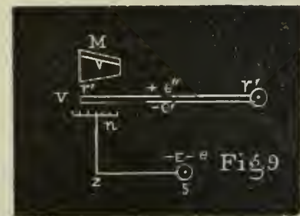
* It is for this reason that the balls s and s' are placed in contact, without which the electricity, $+E'$, passes off by the points n'.

evidently have acted by induction upon the electrical condition of the conductor $n'\ z'\ s'$, and produced an effect; that is to say, it will have repelled the positive electricity upon s', $+\ e'$, (Fig. 8), and at-

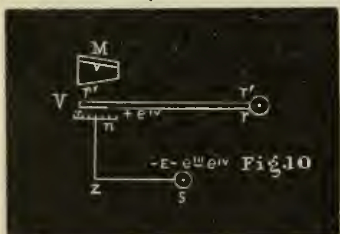


tracted the negative electricity $-\ e'$ upon the face of the plate V*. It follows that the plate when the next half rotation is made, and the first position relative to the armature M is restored, will have a negative electricity, $-\ e$, upon its face $r\ r$, which will be then presented to the points n, (Fig. 9).

8th. A series of analogous actions will also have taken place, that is, the negative electricity, $-\ e'$ of the plate, effects simultaneously a charge in the electrical condition in the armature M, and in the conductor $n\ z\ s$. There will then exist in the armature M a negative electricity $-e'$,



the positive electricity $+\ e''$ escaping by the point of paper which is in contact with the face $r'\ r'$ of the plate. The action of $-\ e'$ upon the conductor $n\ z\ s$ is to repulse the negative electricity $-\ e'e'e'$ upon s, and attract the positive electricity $+\ e'''$, which, having escaped by the points n, neutralizes very nearly the negative electricity $-\ e'$ of the plate. But before the disappearance of the electricity $-\ e'$ in this manner, the electricity $-\ e''$ of the armature M being better retained, passes away by the point of paper, and goes to neutralize the electricity $+\ e''$ of the face $r'\ r'$ of plate (Fig. 10). Thus be-



fore the escape of the electricity $-\ e''$ of the armature M, and whilst it exists in M, it will evidently have excited by induction the conductor $n\ z\ s$, and will have repelled the negative electricity $-\ e^{iv}$ and also have attracted the positive electricity $+\ e^{iv}$, with which the plate is charged anew from the opposite end of the horizontal diameter, whence are reproduced the effects described in section 7, upon the armature N, and upon the conductor $n'z's'$, and also the consequent effects.

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* No notice is here taken of the feeble current which the electricity, $+\ e$ of the armature N, is able to produce on the plate of glass.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LXXI. JUNE, 1876. No. 6.

EDITORIAL.

Notice.—The publication of the Journal is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

The United States International Exhibition of 1876.— The prominent event of the past month has been the opening of the Centennial Exhibition, which occurred on the 10th.

The President of the United States, accompanied by the Acting Vice-President and the Cabinet officers, the Chief Justice and numerous Associate Justices of the Supreme Court, together with the Emperor of Brazil and the Diplomatic Corps of all nations, represented personally the executive government of the nation; while an almost complete gathering of the Senators and members of the House of Representatives was present in behalf of the National Congress; Governors and officials from most of the States of the Union completed the governmental delegation; the Army and Navy of the United States occupied conspicuous places in the procession; and civic and other officials, together with the Commissioners of the Exhibi-

tion and its officers, with other invited guests, were present—the entire number forming a body of about 10,000 persons, who participated directly in the opening ceremonies.*

Exhibitors and others who possessed the right of entry to the buildings, through which the opening procession was to pass, were spectators of the march, and an audience of about 10,000 more persons had collected within hearing of the speeches and music which preceded the event; while the returns of persons entering the enclosure, gave 85,000 more to be present on the grounds. A numerous body of soldiery from Massachusetts and Pennsylvania formed an escort for the President, and preserved the lines before and during the inaugural proceedings.

At 11 A.M., the President came upon the stand, and was received with great applause, and after an appropriate prayer by the Rt. Rev. Matthew Simpson, Bishop of the Methodist Episcopal Church of Philadelphia, and a beautiful memorial hymn by John G. Whittier,† and after receiving a brief address from Genl. Joseph R. Hawley, Presiding Officer of the Centennial Commission, in announcement of the completion of the preparations for the Exhibition; President Grant spoke as follows:

My Countrymen:—It has been thought appropriate, upon this Centennial occasion, to bring together in Philadelphia, for popular inspection, specimens of our attainments in the industrial and fine arts, and in literature, science, and philosophy, as well as in the great business of agriculture and of commerce.

That we may the more thoroughly appreciate the excellencies and deficiencies of our achievements, and also give emphatic expression to our earnest desire to cultivate the friendship of our fellow members of this great family of nations, the enlightened agricultural, commercial, and manufacturing people of the world have been invited to send hither corresponding specimens of their skill to exhibit on equal terms in friendly competition with our own. To this invitation they have generously responded; for so doing we render them our hearty thanks.

The beauty and utility of the contributions will this day be submitted to your inspection by the managers of this Exhibition. We

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* The most noteworthy foreign guest present was Dom Pedro, Emperor of Brazil.

† An extraordinary musical and verbal rhapsody by Sydney Lanier followed Whittier's poem.

are glad to know that a view of specimens of the skill of all nations will afford to you unalloyed pleasure, as well as yield to you a valuable practical knowledge of so many of the remarkable results of the wonderful skill existing in enlightened communities.

One hundred years ago our country was new and but partially settled. Our necessities have compelled us to chiefly expend our means and time in felling forests, subduing prairies, building dwellings, factories, ship docks, warehouses, roads, canals, machinery, etc., etc.; most of our schools, churches, libraries, and asylums have been established within the hundred years. Burthened by these great primal works of necessity, which could not be delayed, we yet have done what this Exhibition will show in the direction of rivaling older and more advanced nations in law, medicine, and theology; in science, literature, philosophy, and the fine arts. Whilst proud of what we have done, we regret that we have not done more. Our achievements have been great enough, however, to make it easy for our people to acknowledge superior merit wherever found.

And now, fellow-citizens, I hope a careful examination of what is about to be exhibited to you will not only inspire you with a profound respect for the skill and taste of our friends from other nations, but also satisfy you with the attainments made by our own people during the past one hundred years. I invoke your generous co-operation with the worthy Commissioners to secure a brilliant success to this International Exhibition, and to make the stay of our foreign visitors —to whom we extend a hearty welcome—both profitable and pleasant to them.

I declare the International Exhibition now open.

After this address, the President, in company with the Director General of the Exhibition, Alfred T. Goshorn, entered the Main Building, at the head of a procession, and passed through it, crossing to Machinery Hall, where, at 1.15 P. M., the large "Corliss" Engine, which supplies motive power for the machinery, was put in motion by the combined efforts of Mr. G. H. Corliss (Commissioner and maker of the engine), the President, and Dom Pedro; and the opening of the Exhibition was consummated by the admission of the public generally.

Previous notices of the construction and progress of most of the principal buildings have been given in our JOURNAL, but for the purpose of record, it is here stated that there have been erected within

the enclosure about 190 edifices, of all sizes; of which the following list gives the area covered by the large ones:—

1. Main Building,	20·1 acres.	5. Memorial Hall,	1·5 acres.
2. Machinery Hall,	11·6 "	6. Women's Pavilion,	0·7 "
3. Agricultural Hall,	9·2 "	7. Horticultural Hall,	0·5 "
4. United States Hall,	2·0 "	8. Various Annexes,	5 to 6 "

9. Separate Buildings, about 150 in number, of which nearly one-half are mere stands. There are in all nearly 75 acres under roof.

The only unfinished buildings at the time of the opening were in the 8th and 9th classes of the above list, and are very generally edifices built by permission, for states or societies, and beyond the immediate control of the Centennial Commission. The grounds, however, are not yet in very good order. The Exhibition itself, on the day of opening, displayed much want of completion of arrangement, besides the numerous vacancies, where no attempt to open the packages had been made; in fact, a thousand tons of merchandise and machinery were then upon the cars, without the gates of enclosure; and as much more was known to be yet upon the seas, to arrive in New York or Philadelphia. Those, however, who had seen the grounds as late as the day before the opening, were much astonished at the completeness and degree of order which had been reached. Even the machinery exhibits, which seemed hopelessly confused at the last moment, were made to assume an appearance of finish and an actuality of starting into work, that was surprising. Since the opening, not quite so much energy has been expended in completion, as the past three weeks have not equaled the accomplishment of the three days ending May 9th; but at this time there remains little to be done in finishing the display. In some of the machinery annexes there are yet many machines not in order for examination; and in the agricultural department, the incompleteness is most marked; France, Russia, Turkey, and the Argentine Republic are behind in all branches of their show; but by the middle of June it can be anticipated that the noise of the hammer will cease upon the grounds.

The successful character of the Exhibition is already established beyond question; the variety, extent, thoroughness and beauty of the several exhibits, exceed the anticipations of the most sanguine of its friends, and far surpass the expectations of the general visitor. That a great share in this result is due to contributions from foreign nations, in which contributions art is shown in every form of beauty,

skill in every branch of industry, ingenuity in every application of mechanism, and intelligence in them all; with that total absence of political feeling that has made it possible for this national occasion, to become, in Philadelphia, a truly international exhibition.

In such an exhibition the only course is for the observer to examine and appreciate for himself that part of the show in which his calling, station or habit of life will give him particular interest. The best in the world is here, the best which can be had or seen, the most attractive show which the nation can make; the appeal to patriotism or to personal desire for profit or honor, has gathered all we can exhibit; foreign nations have entered into a friendly competition and comparison, and national pride and personal profit have stimulated them and their people to aid in their exposition of the progress of civilization; no American exhibition has at all approached this one in beauty or extent, and the success of the project is completed in the present accomplishment.

In the mechanical department of the Exhibition, in which the readers of the FRANKLIN INSTITUTE JOURNAL will have the largest interest, there will be some disappointment to many of those who expect to see novelties of process or production which will possess *popular* interest. It is too early to pronounce certainly that such do not exist; if they do they will become prominently notorious within a brief time; but the character of the mechanical exhibits of the past great exhibitions has gradually changed, until the only things shown freely are the products of manufacture, what people make to sell, and not the appliances for producing these products. And another result from the growth of mechanical industry is the advance from elementary discovery to technical improvement. Possibly a familiar example will convey to the reader the nature of this change. Any person tolerably informed in physics and electricity, who should in 1851, the date of the first great exhibition, have examined the electric telegraph and apparatus, could readily comprehend and popularly describe the whole so that the general reader or listener would be entertained and, possibly, instructed; but to-day, if a fully informed electrician and skillful mechanic were to visit one of our large telegraph offices, he would find apparatus complicated in construction to the last degree, diversified to unlimited extension, and involving in its principles of action the most subtle and abstruse problems, whose comprehension alone could only result from the

closest study or the most constant experience; and any description of accuracy, would fail to convey the least idea to the uninitiated, beyond the fact of the attainment of wonderful results. Similarly the sewing machine has now become involved in detail devoid of general interest to readers. And each development of former days, new and interesting at the time, when the general novelty has passed, has grown in particular interest as a technical subject, and lost otherwise.

The examination of the judges will bring out the most striking novelties in mechanism, and such as will prove interesting on these pages, will be gladly described and commented upon.

Proposed Canal between the Basin of the Caspian Sea and the Black Sea. Filling of the Basin of the Caspian Sea.—Mr. Henry C. Spalding, an American engineer, announces a project for the restoration of the ancient water level of the Caspian Sea to its condition in pre-historic times, by the cutting of a canal, some 170 miles in length, by which the waters of the Black Sea shall be drained into the basin of the Caspian. He has examined the country, and has prepared a report, which is intended to show that it is feasible to commence the work at some point in the basin where the natural surface is 50 feet below the Black Sea level, and to extend a channel westwardly, 500 feet in width, with a level bottom, until 35 feet of fall is obtained; from this terminus of a wide cut, he would continue the channel 15 feet in depth (below the Black Sea level) to some point on the shore of the Black Sea, where the canal would have 10 feet depth—the whole of this shallow canal being 150 feet wide. The ensuing flow of water (at the rate of about eight miles per hour would then be made, by proper direction and assistance, to excavate the remaining part of the earth, and the quantity of water, which would increase with the enlargement of the channel, he estimates would be sufficient in forty years to fill the basin to its capacity, while the enlarged channel would become navigable, and the great trade of Persia would be diverted into the new route. Mr. Spalding proposes further that there be formed a junction between the Don and Volga Rivers, and that the upper stream of the Don be diverted into the Volga, while the lower stream would be severed, and would drain from the Sea of Azof. This additional means of supplying the basin of the Caspian would reduce the time for filling it to twenty-five years.

A new Empire, with a new fertility, new people, and new climate, is anticipated to result from this geographical engineering.

Franklin Institute.

HALL OF THE INSTITUTE, May 17, 1876.

The stated monthly meeting was called to order at 8 o'clock, P.M., the Vice-President, Chas. S. Close, in the chair.

There were present 91 members and 12 visitors.

The minutes of the last stated meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, showing that at their last stated meeting, 11 persons were elected members of the Institute. That the Scott Legacy Premium and Medal were awarded to Morris L. Orum, for his flexible mandril for bending metal pipes ; that the President has appointed the following persons members of the Centennial Reception Committee :—J. E. Mitchell, *Chairman* ; Hector Orr ; H. Cartwright ; W. Helme ; J. J. Weaver ; L. M. Haupt ; J. M. Goehring ; Dr. G. M. Ward ; S. Lloyd Wiegand ; G. Morgan Eldridge ; J. W. Nystrom ; J. S. Bancroft ; Dr. C. M. Cresson ; Wm. M. Henderson ; H. R. Heyl ; S. R. Marshall ; C. E. Smith ; C. S. Heller ; C. Sellers, Jr. ; R. Estrada ; W. H. Thorne ; Thos. S. Stewart ; C. Chabot ; D. D. Willard ; W. F. Durfee ; A. G. Buzby ; Prof. E. J. Houston ; Samuel Sartain ; and that the following donations were made to the Library :

Navy Register of the United States to January 1, 1876. Washington, 1876. From the Navy Dept.

Report of the Board to recommend a standard gauge for bolts, nuts, and screw-threads for the United States Navy. May, 1868. Washington, 1875.

Extract from annual report of the Chief of Bureau of Steam Engineering to the Secretary of the Navy, Oct. 25, 1867. Washington, 1870.

Report of the Trials of the Steam Machinery of the U. S. Revenue Steamers Rush, Dexter, and Dallas, at the U. S. Navy Yard, Boston, Mass., in the month of August, 1874.

Reports of the Chief of Bureau of Steam Engineering for 1871 and 1872, with appendix. Washington, 1873.

Annual Report of the Bureau of Steam Engineering. Washington, 1873–4–5. From the Bureau of Steam Engineering.

Notes for the Guidance of Inventors, being part of a series of Articles by W. Lloyd Wise. Reprinted from Engineering. London, 1875. From the Author.

Burley's U. S. Centennial Gazetteer and Guide, 1876. Philada. From S. W. Burley, publisher.

Officiller Bericht über die Sachsische Gewerbe und Industrie-Ausstellung zu Dresden, 1875. From W. H. Uhland, Leipzig.

Centennial meeting of the Philadelphia Contributionship for the Insurance of Houses from loss by fire. Philada., 1852. From the Philada. Contributionship, &c., April, 1876.

Program der Grossherzoglich Badischen Polytechnischen Schule. zu Carlsruhe für das Studienjahr, 1875–76. Carlsruhe, 1875. From the Polytechnic School.

On the Physical Geography of the part of the Atlantic, which lies between 20° N., and 10° S., and extends from 10° to 40° W., by Captain Toynbec, F.R.A.S., &c. London, 1846. From the Meteorological Committee.

The Magic Square, containing all numbers from 1 to 10,000, so arranged that counting perpendicular, horizontal, or diagonal, every line will count the same. Arranged and presented by Joseph Nicholson, Philada., Penna.

Annual Report of the Supervising Architect to the Secretary of the Treasury for 1875. Washington, 1876. From Wm. A. Potts, Superv. Arch't.

Sixth Annual Report of the President and Directors of the Lake Shore and Michigan Southern Railway Co., to the Stockholders for the Fiscal year ending Dec. 31, 1875. From the Company.

List of Members of the Institution of Mechanical Engineers. From the Institution.

Report of the Tenth Industrial Exhibition, under the auspices of the Mechanics Institute of the City of San Francisco, held between August and Oct., 1875. From J H. Culver, Secretary.

Specimen Fasciculus of a Catalogue of the National Medical Library, under the direction of the Surgeon-General U. S. A. at Washington, D.C., 1876. From J. S. Billings, Assist Surg. U. S. A.

Contributions to the Natural History of Kerguelen Island, made in connection with the United States transit of Venus expedition, 1874–75, by J. H. Kidder, M.D., II. Washington, 1876.

Bulletin of the U. S. National Museum. No. 5, Catalogue of the fishes of the Bermudas, by G. Brown Goode. Washington, 1876.

Annual Report of the U. S. Geological and Geographical Survey of the Territories, by F. V. Hayden. U. S. Geologist. Washington, 1876. From the Dept. of the Interior.

The Actuary also reported the following, adopted at a special meeting held April 25th :

Whereas, This Board has been informed of the death of Geo. Washington Smith, Esq., a venerable and esteemed citizen of Philadelphia,

prominent in philosophy and science during a long life, and a member of the Franklin Institute. Therefore

Resolved, That we recognize him as one of the original friends and founders of the Franklin Institute, who followed us with his works and advice to the completion of our first half century ; that though acknowledging the favor of this long service, we present our deep regret at this, his late and final withdrawal from our fellowship.

Resolved, That we recommend the attendance of members of this Board at his funeral, as a testimony of our respect and sorrow.

Resolved, That a copy of these proceedings be presented to the family of Mr. Smith, and also reported to the Institute at the next meeting.

Mr. Hugo Bilgram then read the paper announced for the evening, being on "The Temperature of the Sun."

The Secretary presented his report, embracing Appleby's Door Mat Alarm ; Curtis' Regulating Gas Burner ; Donghoue's Anti-incrustation Battery for Steam Boilers ; Eccle's Quadruple Screw Press ; a Book Rest for Invalids, the invention of Mr. John McClure ; specimens of two heavy Turning Tools made from scrap steel, and sent by Mr. Chas. Graham, of the Bloomsbury division of the Delaware, Lackawana and Western R. R. ; and a Crook's Radiometer, made by Mr. J. J. Hicks, London.

Under the head of deferred business the subject of the metric system of weights and measures was taken up.

Mr. Briggs, through the Secretary, withdrew the extended minority report, which was partially read at the last meeting, and presented a shorter one which was read.

Mr. W. Jones moved that the majority report be adopted, and that the Secretary be directed to transmit a copy of the same to the Boston Society of Civil Engineers.

Mr. Orr offered the following as a substitute, which, on motion, was accepted, and after much discussion, the resolutions were adopted.

Resolved, 1st, That the two reports of the committee, relative to the metric system of weights and measures be accepted and filed, and the thanks of the Institute be expressed for the same.

Resolved, 2d, That while we decline to ask for, or favor compulsory legislation to enforce a change in our weights and measures at this time, we believe that the adoption of a harmonious system of money, weights and measures, throughout the bounds of mercantile intercourse is most desirable ; and that we stand ready to do our part in the shaping of such a system, and in the application of the same when it has been devised.

Mr. Jones then moved that the majority report be adopted, and a copy thereof be sent to the Boston Society of Civil Engineers, and that both reports be printed in the JOURNAL.

Mr. Bary moved to divide the subject so as to make the matter of printing in the JOURNAL a separate resolution, which was carried.

Mr. Chabot moved to still further divide Mr. Jones' motion, so as to make the question of the adoption of the majority report one resolution, and the sending of a copy to the Boston Society of Civil Engineers another resolution.

Pending the discussion of Mr. Chabot's motion, the further consideration of the subject was, on motion, postponed to the next stated meeting.

On motion, the meeting then adjourned.

J. B. KNIGHT, *Secretary.*

REPORT

To the FRANKLIN INSTITUTE of the State of Pennsylvania, for the promotion of the mechanic arts:

The Committee to whom was referred the circular of the Boston Society of Civil Engineers, asking the co-operation of the Institute "in petitioning congress to fix a date after which the metric weights "and measures shall be the only legal standards," respectfully report:—

The subject of weights and measures, which are *the instruments used in weighing and measuring*, has received the attention of all governments, and always with a desire to promote uniformity. The literature of the subject is copious.

Your committee will not repeat it, except so far as may enable us to determine the propriety of the proposed action. They refer to the admirable report of John Quincy Adams, Secretary of State, made to congress Feb'y 22, 1821,* and to the reports of the Board

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* In Mr. Adams' journal, Feb'y 22, 1821, after speaking of sending to the Senate, the treaty with Spain for the cession of Florida, he says:

"I sent at the same time to both houses, the report upon weights and measures prepared conformably to a resolution of the Senate of March 3, 1817, and one of the House of Representatives, of Dec. 14, 1819."

"And thus have terminated, blessed be God, two of the most memorable transactions of my life."

. . . Of the report he says: "It is, after all the time and pains I have bestowed upon it, a hurried and imperfect work; but I have no reason to expect that I shall

of Managers of the Franklin Institute, made to the legislature in this state in 1834, published in the JOURNAL of that year, for the history of the subject and to the various encyclopedias for information as to the present state of metrology in France.

We are invited to adopt the system of France and to compel our people to use it. With her example before us as a guide, we may contrast with our own:

1. The condition of the weights and measures of France before her revolution.

2 The opportunity presented by the times when the French undertook their change.

3. The character and habits of the French government and people.

4. The system as originally designed by the French commission and as ordained by law.

5. The passive resistance of the people to the changes, the entire rejection and abolition of parts of the system (including all compulsory provisions), the compromise of 1812 in the adoption of the *système usuel*, in combination with the decimal metrical system originally forced upon the people, and the final establishment of this system in 1840.

6. The reasons for this resistance and reaction. And then, after a consideration of the immense number of fixed and recorded measurements now existing in this country, and of the expense, labor, and confusion which the attempt to change them would occasion, we shall perhaps be able to form an opinion as to the wisdom of such an attempt:

1. The condition of the weights and measures in France when the Bishop of Autun proposed a reform, may be described as legal confusion. In the memoir of the Bishop (afterwards Prince de Tallyrand) he enumerates 13 different lengths of the foot (*Pied*) in legal use, measuring from 120 to 150½ *lignes;* 18 different legal yards

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ever be able to accomplish any literary labor more important to the best ends of human exertion, public utility, or, upon which the remembrance of my children may dwell with more satisfaction."

The report is republished in Davies' Metrical System, Barnes, N. Y., 1871. It is a philosophical and judicial investigation of the subject, candidly stating the advantages and disadvantages of the various systems. Quotations from it may be made favoring either side.

(*Aunes*) measuring $299\frac{80}{100}$ to $597\frac{20}{100}$ *lignes;* 21 different legal pounds (*Poids de Marc*) weighing 6479 to 9767 grains; 24 legal *Boisseaux*, containing from 128 to 5157 cu. in.; 17 legal *sacs*, containing 3584 to 7349 cu. in.; 23 legal *septiers*, containing from 924 to 10,830 cu. in., 13 legal *Tonneaux*, containing from 12,203 to 97,989 cu. in., besides others, and adds, "this table is only a much abridged extract "of the principal differences between the weights and measures of "the kingdom."

The situation in France invited reform. There is no such diversity here. The weights and measures are by law, uniform throughout the United States, although slight diversity may exist in fact. The same motive for change does not exist here as existed in France.

2. The opportunity presented to France was peculiarly favorable for a change. The new system was struck out during the red heat of the revolution, during which the king was dethroned and beheaded, the nobles were killed wherever found, and their property, when they fled for their lives, was plundered or confiscated. The priests were driven from their cures, and religion was abolished. The Christian era disappeared and the world began again at the year 1 of the French Republic, upon the 22d of September, 1792, "the day of the autumnal equinox, when the sun entered the sign of "the balance, the symbol of equality."

However, favorable to the introduction of a perfect system of weights and measures, your committee hope that no such opportunity may be presented in this country.

3. The government of France has always been in the habit of interfering with the private affairs of the people. For instance: the prices of butchers' meat and of bread are fixed by the prefects of police. A journeyman may not engage with a master mechanic without the permission of the same officers, etc., etc. The people are accustomed to this parental care, and would feel lost if it were withdrawn. They will, if necessary, rise up and destroy the government, but while it *is* the government, they are accustomed to feel its hand in their private affairs. A law, which proposed to abolish the old weights and measures in use, and the old habits of the people in weighing, measuring, and trading, and to substitute new ones with new names, would be more likely to be obeyed when enacted by the government of France than by that of the United States.

This government is authorized by the constitution to "fix the standard of weights and measures." It would be questioned whether this power "to fix," meant to change, to abolish, and to substitute new and foreign weights and measures. Our general government has never undertaken to enforce the laws to maintain the existing standards. The supervision of the subject has always been the care of the separate States. A law of the United States, such as proposed, would probably be a dead letter unless enforced by means which the people would not submit to. The American idea of government duties is, that it should do and enforce justice, and that Liberty in all things innôcent, is the birthright of the citizen.

4. The system established by the French, and the difficulties of the undertaking, may best be understood from a brief chronological sketch.

In 1790, Talleyrand addressed a memoir to the constituent assembly, setting forth the condition of the existing metrology and proposing to establish a new system for all France, whose primary unit should be the length of a pendulum beating seconds, as a natural standard. His proposition did not embrace a decimal system.

A decree, adopting the proposition, but with serious modifications was sanctioned by the king, Louis XVI, upon the 22d of August, 1790.

In execution of this decree, a committee of the Academy of Sciences was appointed to examine and report upon the subject. The report was made August 19th, 1791. It proposed the ten millionth part of a quadrant of the meridian as a natural standard unit of lineal measure to be applied as a measure of matter in its three modes of extension, length, surface and solidity; and as a secondary standard of comparison with this unit. the length of a pendulum vibrating one hundred thousand beats a day. The weight of distilled water contained by a cubical vessel in decimal proportions to the lineal measure, was to be the standard unit of weight. The whole system of weights and measures was to be composed of multiples and subdivisions of these units according to the decimal system. The report recommended that the quadrant of the arc of the meridian should be divided into 100 degrees instead of 90, as before. The decimal division of time also was part of this plan.

To carry this plan into effect it was necessary, with the utmost accuracy, to measure the arc of the meridian, to weigh the ascertained

bulk of water, and to find by experiment, the length of the pendulum beating 100,000 seconds per day. The report being sanctioned, the execution of the scientific observations was immediately begun, but was not completed before seven years, owing to numerous interruptions, occasioned by the overthrow of the government and the abolition of the Academy of Sciences.

Upon the 5th of October, 1792, the new calendar was established by law. It made 100 seconds in a minute, 100 minutes in the hour, 10 hours in a day, 10 days in a week, 3 weeks in a month, and 12 months in a year. Thus 100,000 seconds made a day, 30 days made a month, and 360 days a year. The five or six odd days in the natural year, having no month to cover them, were called in derision *Sans Culottides*, or, days without breeches, and were devoted to games and frolics.

The quadrant of the circle was also divided decimally into 10 parts and each part into 10 degrees. The quadrant of the meridian containing 100 degrees of 100,000 *metres* each, was to be 10,000,000 *metres*, and the circumference of the earth, forty millions of *metres* in length.

The universe, under this system, might be compared to a great French clock, having the earth for its escape wheel, whose equatorial motion would be 400 *metres* per second.

The National Assembly, impatient at the delay in establishing the definitive *metre*, decreed upon the 1st of August, 1793, that the system should go into operation immediately, based upon a measurement of a degree of the meridian made in 1740, which made the length of the *metre* $443\frac{44}{100}$ *lignes* of the ancient French foot. This decree adopted a complete nomenclature of all weights and measures for lines, surfaces and solids. The length of the *metre*, and values of all measures derived from it, were to be provisional and lawful until the final determination of the correct figures. The new nomenclature and the use of 100,000 seconds per day, were made compulsory by the law of 24th November, 1793.

By the law of 7th April, 1795, some of the names were changed and the existing nomenclature of the French metrology was *definitively* established, although the sizes of the weights and measures were *provisional* only. This law provided that the weights and measures might be made of the units, ten units, the double units, half units, and tenth units, but no other multiple or subdivision, such as

$\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{6}$, $\frac{1}{8}$, should be made or used. The same law re-established the scientific commission for the work of determining the definitive *metre*, etc., and repealed so much of the law of 24th November, 1793, as obliged people to use 100,000 seconds in a day.

The arc of the meridian between Dunkirk and Barcelona was measured by Messrs. Delambre and Mechain, with great accuracy. It comprehended about $9\frac{2}{3}$ degrees of latitude. The measurement was continued south by Messrs. Borda and Biot to the island of Formentara, so as to comprehend 12 degrees of latitude, of which, 6 were south of the 45th parallel, and 6 north of it.

The degrees of latitude were found to be of different lengths and the differences followed no law. An average was therefore taken, and then the length of the *metre* was determined to be $443\frac{296}{1000}$ *lignes* of the old French foot (being $\frac{1}{100}$ of an inch less than the provisional *metre*) and equal, according to the measurements of the French Academy, to 39·3827 in English; of Captain Kater (English), 39·37079; of Mr. Hassler (U. S. Coast Survey), 39·3802. Doubts have been thrown upon the correctness of all these measurements.

The length of the pendulum vibrating 100,000 seconds per day at Paris was found to be ·74193 *metres* (29·2192 in.), from which was afterwards deduced by calculation, the length of the pendulum vibrating the usual seconds of 86,400 a day, equal to ·99383 *metres* (39·1393 in.) or $440\frac{56}{100}$ *lignes* of the old French foot.

The weight of distilled water contained in a cubic *decimetre* was found to be $18·827\frac{15}{100}$ grains French, equal to $15·445\frac{72}{100}$ grains troy, which is the weight of the *kilogramme.*

The capacity of the vessel containing this water is the capacity of the *litre*, which is equal to 61·02624 cubic inches. This is the standard unit for wet and dry measure.

The principle of decimal arithmetic was applied to all these units. The multiples were tenfold, and the subdivisions were tenths, so that in any sum representing French measures, each figure has ten times the value of its right hand neighbor. To all the multiples of the system, Greek words are prefixed, and to all the subdivisions, Latin words.

The actual standard measures of the *metre* and the *kilogramme* were deposited with the keeper of the public archives, with great form and ceremony, upon the 22d of June, 1799.

The temporary weights and measures provided by the law of August 1st, 1793, were abolished and the definitive substitutes were established by law upon the 10th of December, 1799.

The establishment of the French decimal metrical system has thus far been described. The process of modification and repeal of compulsory measures followed. We have already seen that the law of April 7th, 1795, repealed the compulsory use of the second of $\frac{1}{100,000}$ of a day. This was a revolt against "decimal despotism."

On the 8th of April, 1802, a law was made, retaining the republican calendar for civil purposes, but restoring the week of seven days and the old Sundays.

By the law of November 23d, 1802, the wine trade was relieved from the compulsory use of the new system, which required that the casks should contain a decimal number of *litres*. It was now permitted that the casks might be made of the ancient sizes and the contents in *litres* branded upon them. In the newspapers at Bordeaux the prices current at this day are quoted by the *tonneau* of 4 *bariques*.

On the 9th of September, 1805, the new calendar (after an existence of twelve years) was abolished, and the ancient calendar was restored, so that January 1st, 1806, reappeared.

On the 12th of February, 1812, an imperial decree, executed by an ordinance of 28th of March, following, abolished the compulsory provisions of the decimal system so far as to permit the use, for the purposes of commerce, of the following weights and measures:

Lineal measure.

- *Toise* = 2 *metres*, divided in 6 feet. On one side divided into *decimetres*, and the first division into *millimetres*.
- *Pied* = $\frac{1}{3}$ *metre*, divided in 12 inches, each inch in 12 lines. On one side divided into $3\frac{1}{3}$ *decimetres*, and subdivided into *centimetres* and *millimetres*.
- *Aune* = 1·2 *metres* divided into $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{3}$, $\frac{1}{6}$, $\frac{1}{12}$. On one side marked in decimals of *metres*.

Capacity.

- *Boisseau* = $12\frac{1}{2}$ *litres*, also its double, half and quarter.
- *Litre* = also its subdivisions of $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ for retail sales of wet and dry measure.

Weight.

- *Livre* = $\frac{1}{2}$ *kilogramme* or 500 *grammes* = 16 *onces*, also subdivisions of $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$-ths.
- *Once* = 31·25 *grammes* = $\frac{1}{16}$ *livre*, also subdivisions of $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$.
- *Gros* = 3·90625 *grammes* = $\frac{1}{8}$ *once*.

Thus after twenty years of contest and confusion, the old names and the old subdivisions were restored, but with new and uniform values.

This led to many years of confusion and fraud, followed by another change, decreed by the law of July 4th, 1837. This law was executed by the royal decrees of April 17th and July 10th, 1839, and put in operation in 1840, when the existing decimal metrical system was finally established, after a struggle of 47 years, a period of two generations, during which the entire active population of France was changed.

The preceding history is given to show the extreme difficulty of effecting a change in the weights and measures used by the people, even when a reform was most needed, because of the greatest confusion and diversity of the weights and measures in use, and when the change was enforced by the most bloody and arbitrary despotism of modern times, favored by the best of opportunities.

Although the *metre* was drawn from the circle and the sphere, these two forms resisted the application of the decimal metrical system. The measurements of time, of the degrees of the circle, of navigation, geography and astronomy, successfully rejected it, although the prime idea of the Commission was to connect these subjects with ordinary weights and measures, by making the *metre* (the 40 millionth part of the circumference of the earth), *the unit of lineal measure*, and the *second* (the hundred thousandth part of the day) the *unit of time*, by means of the pendulum beating 100,000 seconds. The *metre* and the *second* were then the intermediate links in a long chain connecting science and practical life, having the solar system at one end, and a quart measure at the other. It is singular that the parts of this chain applicable to the calculations of science, were at once abandoned for their inconvenience; and the parts applicable to the uses of yard sticks, pound weights, and quart measures, were imposed upon the people by compulsory laws for nearly twenty years, without regard to the still greater inconvenience to them.

Excuse for this partiality may be found in the facts, that the division of the day into 86,400 seconds, and of the quadrant into 90 degrees, was uniform throughout France, and throughout the world; that, although the day and the quadrant were not decimally divided, they were conveniently divided according to the nature of things; that there was a great value invested in the clocks and watches, and instruments for measuring time and circles, and in the tables and

calculations already made for the purposes of navigation, mensuration and astronomy, which would become useless if the changes were persisted in.

In fact, there were all the reasons for not making these changes, which we have now against the changes proposed to us; and there was no stronger motive. These reasons prevailed, and these changes were abandoned.

From these remarks we may infer why the French people resisted a reform conferring such benefits upon the nation, and perfecting its unity. Of course, the first objection was that it was a change; a change which required them to unlearn much of their little learning, to abandon many of their old customs, and to embrace new things with outlandish names. The philosophers laughed at this reason, but they yielded to it themselves.

If this objection had existed alone, the strong hand of the government—persisting for twenty years—must have conquered it. But there were other and more enduring reasons. The new system was not so perfect as to be in all cases preferable to the old. The usual divisions and subdivisions of weights and measures are the result of the natural selection of thousands of years, and they are in harmony with the daily wants and usages of practical life, requiring divisions of quantities into halves, thirds, quarters, sixths, and eighths, not always convenient in decimals.

But whatever were the controlling reasons which incited the opposition to a change in France, they have much greater force with us from the absence of motive. We have no such confusion and diversity as the French had, and no such reform is called for. Our money is already decimally divided, and we enjoy already the chief benefits which the new system gave to the French.

If the measurements of the weights and the dimensions of substances, when ascertained, were only to serve as data for complicated calculations, the reasons for adopting weights and measures decimally divided, would have controlled the practice long ago. This is actually the case with us; in surveying land, which is measured by chains twenty-two yards long, divided into one hundred links; in civil engineering, when embankments, excavations, etc., are measured by yards and tenths, or feet and tenths, as the case requires; in the measurements of ships for tonnage, when the three dimensions are taken by feet and tenths; and in gauging casks, which is done with a gauging rod marked in inches and tenths.

But the fact is, that the vast majority of weighings and measurings are followed merely by mental calculations ; or, by a simple multiplication of quantity (whole or fractional) by price (in decimals), a process which can oftener be done by vulgar fractions, more easily than by decimals.

The *metre* is really as arbitrary a standard as the foot. About 80 degrees of latitude have been measured, but no two of them have been found of the same length, and there is good reason to believe that the length is not permanent in the same place. The only real thing about it is the rod in the public archives. The length of the *metre* is to be recovered, if lost, by comparison with the length of the seconds pendulum, and so likewise is the length of the foot or yard.

The *metre* was adopted in France for the lineal unit, in preference to the length of the seconds pendulum, only because the harmonious proportion between the *metre* and the length of the meridian would bring all local measurements into harmony with the measurement of the world, and would be a great assistance in geography and navigation; but the decimal divisions of the quadrant and of time, having been abandoned, and the adopted length of the *metre* having been found incorrect, there remains not even a sentimental reason for our adopting it as our unit of measure. Our own convenience should be our guide, and overwhelming reasons forbid us to incur the confusion, labor and expense of attempting to make a change of that kind.

In the opinion of your committee, the *metre* in any shape heretofore adopted, is a less convenient instrument for measurement than a two foot rule. You cannot fold it into four without breaking the sub-units. If so folded, it would be ten inches long, which is inconvenient for the pocket. The *metre* is only decimally divided, whereas the foot rule, besides being divided into tenths and hundredths, is also divided into twelve inches, and gives the even $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{10}$, $\frac{1}{12}$ and $\frac{1}{100}$ of the foot, and the $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{8}$, $\frac{1}{10}$, $\frac{1}{12}$ and $\frac{1}{16}$ of the inch.

By changing our unit of lineal measure for the sake of uniformity with France, we should sever our uniformity with Great Britain, a country with which three-fifths of our foreign commerce is transacted.

The change in our units would entail much greater expense than is usually imagined. The measurements of every plot of ground in the United States have been made in acres, feet and inches, and are

publicly recorded with the titles to the land, according to the record system peculiar to this country. Hundreds of years would elapse before we could permit ourselves to forget these old measures. Besides this, the industrial arts during the last fifty years have acquired a far greater extent and precision than were ever known before. Take, for instance, the machine shops, in which, costly drawings, patterns, taps, dies, rimers, mandrils, gauges and measuring tools of various descriptions for producing exact work and repetitions of the same with interchangeable parts, are in common use.

It has been calculated that in a well regulated machine shop, thoroughly prepared for doing miscellaneous work, employing 250 workmen, the cost of a new outfit adapted to new measures, would not be less than $150,000, or $600 per man.* If, instead of changing the sizes, we adopt the alternative of giving the French dimensions to the old sizes, the irreconcilable discord between the inch and the divisions of the *metre*, would furnish a precious example of the simplicity of the decimal system.

If new weights and measures are to be adopted, all the scale beams in the country must be regraduated and readjusted; the thousands of tons of brass weights, the myriads of gallon, quart and pint measures, and of bushels, half bushels and peck measures, and every measuring rule and rod of every description throughout the land, must be thrown aside, and others, which the common mind cannot estimate, must be substituted.

The great mass of English technical literature would become almost useless, and must be translated from a language which we, and the nation we have most to do with, understand perfectly, into a new tongue, which is strange to most of our people. As a question of cost, let those who advocate this change consider it carefully.

To the teacher, to the closet scholar, to the professional man, to those who never handled a rule or a measure, but only use weights and measures in calculation, it may seem merely a matter of legal enactment; but to the worker, the dealers in the market places, to those who produce the wealth and prosperity of the land, the question is a most serious one.

The Franklin Institute has never placed itself on record as opposing true progress; it has always advocated changes which were

* See "The Metric System in our workshops, &c.," by Coleman Sellers—JOURNAL OF THE FRANKLIN INSTITUTE, June, 1874.

beneficial and not destructive. In this case, a majority of your committee believe that the ultimate benefits of the change proposed, would be of less value than the damages during the transition. They think that the government of the United States has already done all that can fairly be asked of it by the most enthusiastic advocate of the metrical system, by making it legal. Those of us who choose to do so, can use that system, and no one can object to it; but, for the government to require us to use that, and no other, would be an arbitrary measure which we are neither willing nor able to bear.

The majority of your committee are of opinion, and so report, that the objections to the attempt to adopt the *metre* as a standard unit of lineal measure, are overwhelming, whether we consider the compulsory means proposed, or the end to be attained.

All of the objections to the metrical decimal system do not apply to the adaptation of the decimal scale to our existing units. In the decimal harmony between the cubic foot and its content of water weighing 1000 ounces avoirdupois, whereby a cube of $\frac{1}{10}$ of a foot on the edge becomes the measure of the ounce of water, we have the means of constructing a decimal system of weights and measures which would interfere the least with existing institutions. But your committee do not feel called upon to consider this branch of the subject.

COLEMAN SELLERS.
W. P. TATHAM,
Chairman.

Philadelphia, April 19th, 1876.

REPORT

To the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts.

The undersigned, the minority of the Committee of three to whom was referred the circular of the Boston Society of Civil Engineers, asking the co-operation of the Institute "in petitioning Congress to fix a date, after which the metric weights and measures shall be the only legal standards;" respectfully reports: That while he agrees with the conclusions of the majority of the committee, so far as relates to the subject specifically referred to them, that it is inexpedient

to attempt at present to anticipate, by enactment, the time when this great step in the progress of human civilization and unity, shall be taken by the national government of the United States; he does so solely upon the grounds of the yet incomplete preparation and education of the people; and their want of appreciation of the immense advantages in the progress of the arts, and in the applications of science which the metric system presents.

It having been decided by the Board of Managers that it is inexpedient to publish, in extended form, the statements and arguments which have been prepared by the minority of the committee in support of his views, it is therefore considered by him most proper to restrict this report to a simple protest against the tenets and assertions of that of the majority, as already published and circulated.

The undersigned protests against the perversion of history set forth in the majority report; wherein the struggle by which an uneducated, and at the time, lawless people emancipated themselves from the trammels of their hereditary customs, and acquired a uniformity in the system of weights and measures, is made to appear as a defect in the result finally attained. The perversion of history, which sets forth as examples what transpired from 1793 to 1812, couples with it an unwarranted assertion as to what transpired from 1812 to 1840, and ignores altogether everything which has occurred in the progress of nations during the past thirty-six years. The perversion of history that looks back to the school-boy days of our older active members, and with the repugnance to change of the most conservative old man of 1840, accepts the conclusions that "The usual divisions and sub-divisions of weights and measures are the result of the natural selection of thousands of years, and they are in harmony with the daily wants and usages of practical life, requiring division of quantities in halves, thirds, quarters, sixths, and eighths, not always convenient in decimals." To an American of any position in life, the absurdity of this allegation, (from which, by strict analogy of reasoning, it would follow, that the old £ s. d. were superior to our decimal coinage), has only to be stated to be appreciated; and to the Frenchman of like social condition, the application of this paragraph to the metric system might provoke merriment, but it could not appear to need serious reply.

The undersigned protests against the statements as to the convenience, suitability, or permanency of our present complicated and

diverse measures and weights—those of land or other lineal measures—the bushels, pecks, quarts—the gallons, quarts, pints—the pounds, ounces, grains—and especially against the averment that the "common mind" can estimate these irrational and disconnected magnitudes more perfectly than those which have simple and definite multiples and relations. The undersigned also protests against the whole line of argument which is, or may be, based on the assumption of great or immediate cost which will accompany or follow the introduction of the metric system; and particularly that excessive cost will ensue in the machine shops, where men work to gauges only, and where measures of length are unknown, except for computation.

Above all, and finally, the undersigned protests against the entirely erroneous assumption of the majority of the Committee, that it is "the teacher, scholar or professional man, who desires for himself the introduction of the metric system"—the truth is completely the reverse. To the teacher, the scholar, or the professional man the introduction of the metric system is of the least consequence. Those who have the habitude to use figures freely in computation, whose avocations keep their minds always awake to the relations of magnitudes of various orders and to the physical units of matter, are not embarrassed nor burdened seriously by the use of a few figures over and above what are absolutely requisite. It is the practical man only, who will reap the great advantage from the simplification of processes of estimates, which result from the metric system. His language of computation will then become in notation, that of ordinary figures, while, whatever his calling or business, he will find himself in possession of the key to the figures, dimensions or magnitudes of all other pursuits. He will be made free to apply for himself those studies of the practice of the arts which we call sciences, and he will be able to see intelligently the results of the practice of others in his own land and country, and by the spread of the metric system, that of all other nations.

The universal introduction of the metric system is merely a question of time. Within a century probably, it will be established in our own land. Possibly another century may pass before its complete adoption is consummated. Upon the progress of education mainly, but partly upon intercourse with other countries using the system, the period of time before which our people will come to understand the advantages to be gained, will be less or more remote; but sooner or later our people will voluntarily impose upon themselves the learn-

ing of how to use the metric system. Its use for all purposes of computation will follow almost instantly, and your committee believes, without demand for so stringent compulsory enactment as has recently been enforced in Germany.

That the Franklin Institute should carefully preserve its record in the cause of the advancement of science and the arts, is a point on which its members should feel the greatest interest, and exercise the most watchful solicitude. Its advocacy and support to all measures of improvement, however remote the end, should be asserted and maintained at all events, and the acceptance of the report of the majority as an expression of the views of the Institute as a body, should be carefully avoided. If, in the rivalry of kindred societies, we neglect to avail ourselves of one of the steps, which, more than all others, goes to smooth the road to learning; one which pre-eminently offers, after a few months' training, to the grown workman, or by the preliminary education of the child, who is to become a workman, the facility to use and comprehend the figures and computations of his calling; one that simplifies and reduces the quantity of arbitrary learning, which has so embarrassed human progress in past ages; if we, of the Franklin Institute, neglect, or fail to assert ourselves in behalf of advancement, we will be surpassed and displaced in the reputation we have hitherto supported and maintained.

Still, while the minority of your committee is firmly of opinion that the Franklin Institute should *favor* to the utmost, the immediate introduction and use of the metric system, he is free to admit that the time has not yet been reached, when the people are prepared for enforcement, either by voluntary or legal action; and in view of this fact he offers the following preamble and resolutions for the consideration of the Institute. Signed,

ROBERT BRIGGS,

Minority of Committee on compulsory introduction of the metric system.

PREAMBLE.

WHEREAS, Sufficient time has not elapsed since the passage of the act of Congress, giving permissive lawful use to the metric system, to exhibit the progress of the adoption and employment of the same, or to allow any definite opinion as to the future of the introduction of the system in the United States, and

WHEREAS, A compulsory law ought only to be based upon popular requirement and urgent necessity; therefore,

Resolved, That, in the opinion of the Franklin Institute, the time has not yet come, when an enactment by Congress should fix the date for compulsory use of the metric system.

Resolved, That the Secretary be requested to communicate this action of the Franklin Institute to the Boston Society of Civil Engineers.

COMMUNICATION.

To the Editor of the JOURNAL OF THE FRANKLIN INSTITUTE:

I beg leave to offer to the JOURNAL the following abstract of my remarks, in the discussion of the reports of the Committee upon the compulsory use of the Metric System, made at the stated meeting May 17, 1876.

Yours,

JOHN W. NYSTROM.

Upon the subject now under discussion—the acceptance by the Franklin Institute of the majority report which has been made to it—I wish to remark:

The majority report has been printed and circulated in pamphlet form, as if approved by the Institute, and is opposed to recommending the adoption of the metric system in this country; to which opposition of the committee, I have no objection: but before that report is adopted by the Franklin Institute, it is desirable that it should be based upon tenable ground, and not uttered in that spirit of depreciation of the metric system, and of the French nation, which seems to have inspired the Committee. That nation deserves great consideration for its struggle to introduce a universal system of metrology; an enterprise which, although universally desired, no other nation has ventured to undertake.

The majority report expatiates upon objections to the introduction of the metric system in this country, which are of mere temporary and insignificant import, very much like the English objections to the introduction of the Arabic figures for the Roman notation some 300 years ago. The English were about 400 years behind the Continental nations in the introduction of our present Arabic digits. The English thought that the introduction of the Arabic figures for the Roman notation, would obliterate all records and reckoning, and they expatiated upon the great difficulty and expense in making the alter-

ation. Now, the majority report on weights and measures to the Institute, is conceived in the same spirit, in regard to the introduction of the metric system. What would our technical books, our arithmetic, reckoning and records be to-day with the Roman notation ?

At the April meeting of the Institute, it was remarked that the majority report was *practical*, and the minority report *theoretical*. In England, about 300 years ago, the Roman notation was considered *practical*, and the Arabic notation *theoretical*, and this identical distinction between *practice* and *theory* appears to prevail at the Franklin Institute to-day. The terms *practical* and *theoretical* are promiscuously used at the Institute, as a means of support to sciolism and perversion of the truth.

The difficulties which the French have experienced in establishing and introducing the metric system, are not tenable reasons for rejecting its adoption in this country. The difficulties Fulton had in introducing steam navigation, are to-day no objections to its use. The same can be said about Morse and the telegraph, and many other valuable advances upon which our progress and prosperity depend. The Republic of Switzerland and other nations who from French example have adopted the metric system, did not experience the difficulty with their *reamers* and *mandrils*, as intimated in the "practical" report.

The duty of technical and scientific men should be to consider, investigate and explain impartially, the comparative merit and demerit of the French and of our present system of metrology in all their bearings, and leave it for the law-makers to decide whether or not it would be expedient to introduce, or if necessary to enforce the metric system upon us. The majority of our committee, however, have taken it upon themselves to speak, not only for the Franklin Institute, but as though they represented the entire United States.

We have no substantial reasons for supposing that our law-makers would enforce unjust laws, and the Americans are generally a law-abiding people upon whom various laws are enforced every day. It is not for the Franklin Institute to decide whether or not the introduction of the metric system in this country would be an unjust law. We know from experience, history and tradition, that in all parts of the civilized world, communities do not always comprehend their true interests, and it has therefore been found necessary sometimes, to enforce laws by which to guide them into prosperity, as was the case in

England, with the introduction, adoption and enforcement of the Arabic figures for the Roman notation before mentioned. The enforcement of the Arabic figures in England, was made at the expense of burning the Houses of Parliament.*

In case our law-makers should find it expedient to introduce or enforce the metric system upon us, they will no doubt give at least ten years' notice, in which time the present *reamers* and *mandrils* in a tool shop may be worn out, and if not, they will not be likely to conflict with any clause in the new law.

The "practical" committee says, "the Franklin Institute has never "placed itself on record as opposing true progress." This statement conflicts with the tenor of their report, and moreover cannot be sustained in an impartial argument. The same committee is "favor- "able to the introduction of a perfect system of weights and meas- "ures," but they at the same time "hope that no such opportunity "may be presented in this country." If this paradoxical language is approved by the Franklin Institute, it may be interpreted and understood that this Society favors progress, but will not give any opportunity for it. I admit that to be true, because I have experienced the fact, but fear that such acknowledgment on the part of the committee would weaken the strength of their report. The same committee refers to an article published in the JOURNAL OF THE FRANKLIN INSTITUTE, headed, "The Metric System in our Workshops," which article contains the same kind of feeble ideas on weights and measures, as those in the "practical" report. The "practical" committee says: "The universe under this (metric) system, might be "compared to a great French clock, having the earth for its escape- "wheel, whose equatorial motion would be 400 metres per second." They evidently expect that such a "practical" idea is good enough to be approved by the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts. The "practical" report is intrinsically imprudent, and, moreover, is ungrateful to the French Government and people, and if adopted as it now reads, it will *stamp a mark of old-fogyism* upon the Franklin Institute, which can never be wiped out, and under no consideration can that report accomplish the effect intended by its authors.

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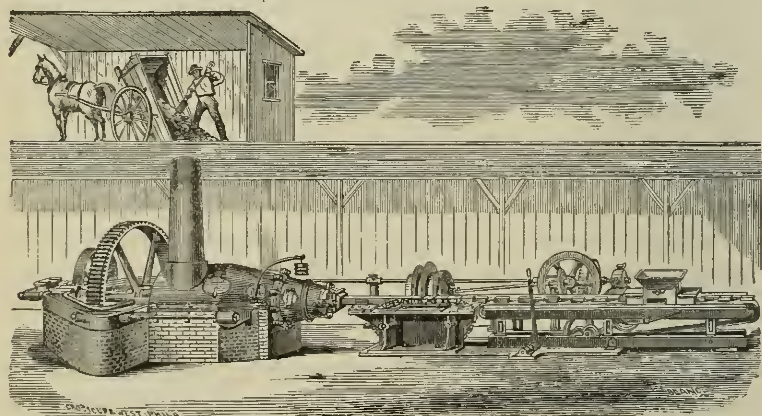
* It is a curious fact that the burning of St. Stephen's Parliament Houses was occasioned by the bon-fire of "tallies" of the old Exchequer accounts, which was made in a court yard.

I beg to be distinctly understood, that I do not advocate the introduction of the Metric System, nor am I against it or opposed to it; but only desire to see dispassionate justice done to it, and therefore feel it a duty to remonstrate against an unphilosophical and hasty disposition of so grave a subject, by a prejudiced Committee of our Society. The tenor of the "practical" report, moreover, seems to border so closely upon arrogance and partiality, as to be scarcely admissible by any institution of learning. A report of this kind ought to be devoted principally to substantial and essential facts bearing directly upon the expediency or inexpediency of introducing the metric system as the only legal standard of weights and measures in this country.

Description of Chambers, Brother, & Co.'s Archimedean Brick Machine, Philadelphia, Pa.*—This machine belongs to the class known as "*tempered-clay machines*," or "clay-tempering, brick-making machines," and was invented by the junior member of the firm, Cyrus Chambers, Jr., who is already well known to the public as a mechanic and inventor.



Chambers, Bro. & Co's Archimedean Brick Machine, Philadelphia, Pa.

The machine is constructed almost wholly of iron, and is made very strong and durable.

It *tempers its own clay with water*, taking the clay as it comes from the bank, without any *previous handling or preparation*, and forms it into bricks, with well-defined corners, and smooth, straight surfaces,

* Paper read before the meeting of the Franklin Institute, April 19, 1876.

at the rate of from fifty to eighty per minute, or from twenty-five to thirty-five thousand per day of ten hours.

The clay is taken direct from the bank and dumped at the side of a conical funnel that leads into the tempering case of the machine, and mixed, when necessary, with *loam, sand, or coal*, and the requisite amount of *water* being added to temper the clay to the proper consistency; the mass is shoveled into the hopper and falls into the machine.

The tempering portion of the machine consists of a strong iron case, in which revolves a horizontal shaft, into which are set spirally, strong tempering knives, or blades of steel, so that, as they pass through the clay, they move it forward. The clay being stiff, and not having much water on it, is not liable to *slip* before the knives, but is cut through and through, and *thoroughly* mixed; so that by the time it reaches the small end of the tempering case it is ready to be formed into bricks.

On the end of the tempering shaft is secured a conical screw, which revolves in a cast-iron conical case, the inside of which is ribbed, lengthwise, so as to prevent the clay from revolving in it, and is chilled, to prevent wearing.

The screw being *smooth* and very hard, the clay slides on the screw, thus becoming, as it were, a *nut;* the screw revolving, and not being allowed to move backward, the clay *must* go forward.

This operation further tempers the clay, and delivers it, in a solid, round column, to the *forming die*, which is of peculiar construction and form, and so designed as to reduce the round column to a rectangular one, whose breadth and thickness is the *proper breadth* and *thickness* for a brick, while at the same time it *forces the clay into the corners* of the square or rectangular, finishing part of the die, so that the angles of the bar of clay are made very solid and sharp, thus insuring perfectly square and well-defined corners to the bricks.

This bar, as it issues from the die, is conducted by a plate to the cutting device, which consists of a thin blade of steel, secured to the periphery of a wheel, in the form of a spiral, the distance between the blades of which is that required for the length of a brick.

This spiral knife runs perpendicularly, in an endless chain, which supports the bar of clay at one edge and bottom, so that the blade in passing through, the clay being supported, thus insuring the angles unbroken, and the cutting smooth and square.

The distance between the spiral blades being uniform, the lengths of the brick are absolutely uniform, thus overcoming the great practical objection hitherto existing in the Chambers' machine.

The drawing cut of the spiral, cuts the end of the bricks perfectly smooth, thus correcting another defect hitherto existing in this class of machines.

The speed of this spiral cutting blade is controlled by the clay itself; hence no matter how irregular the flow of clay, the spiral runs in exact unison therewith; consequently, the absolute uniformity in the length of the bricks.

This controlling of the speed of the spiral by the clay is so positive with that of the clay, that it will run at any speed, from one to one hundred bricks per minute, while the machine runs at full speed.

These cutting and regulating features are the new parts, and overcome the only valid objection heretofore urged against this machine as now introduced.

The bricks, thus cut from the continuous bar, are separated and carried by another endless belt through the dusting or sanding machine, which consists of a chamber, into which is thrown, by centrifugal force or a blast of air or steam, a continuous cloud of dust or fine sand, which adheres to the surface of the bricks, rendering them much nicer to handle, preventing them from sticking together on the barrows, or in the hacks on the *drying cars*, and much improving them in color when burnt.

Provision for Stones—All brick clays have more or less stones in them, and as it is impracticable to pick them *all* out, there is a necessity of making some provision for them, even if there should be only *one stone* in every "ten thousand of clay."

The tempering knives run six inches from the tempering case; hence there is no danger of a stone five inches in diameter catching between the end of the knife and the case, but they frequently imbed themselves in the clay that occupies the space between the ends of the knives and the case. If the stone is more than three inches in diameter, it will lodge at the entrance of the screw, preventing the clay from passing to it, and causing it to issue at the *safety valve*, through which the stone may readily be removed. If a stone, less than three inches in diameter, it will go through the screw, the openings between the threads being *less* at the entrance than at any other point, so that a stone that once fairly enters the screw, cannot lodge

until it has reached the forming die, where it will lodge, if it is *larger than a brick is thick*, and prevent the proper flow of clay, causing the bar to split in two, or only part of a bar to issue. This forming die is secured to the screw-case fly a *hinge* and *hook-bolts*, so that in less than one minute the die can be swung open and the stone knocked out, when the die is closed and the machine again started.

Small stones occur much more frequently, and pass freely through the machine, being buried in the bar of clay and passing to the "cut-off." When the stone should happen to be buried in the bar of clay at the line of severance, the knife must either cut through the stone, be broken, or some provision made by which it shall not be injured. The first is not practicable, as the stones are often very hard, and to break a knife every time it should happen to strike a stone would render the machine useless.

In order that the knife should not be affected by stones, the wheel to which it is secured is held in position by a spring which holds it with *just sufficient force to compel the knife to pass through the bar of clay.* When the knife comes in contact with any hard foreign substance, as stones, brickbats, or bones, the spring yields, and allows the knife to move back, and thus cuts to it, the knife immediately returning to its original position, ready to cut through the bar again—as the inventor demonstrated, by accidentally allowing his hand to remain in the cutting device when the knife came round, cutting two fingers "*to the bone*," when it yielded, leaving the bone uninjured, and the machine ready to cut the *next brick*.

This machine moulds the bricks stiff enough to be "hacked" at once in the drying sheds.

With these recent improvements, the inventor claims this machine to be the most practicable, durable, and economical brick-making machine yet introduced.

Improvement of the Passage over the Bar at the South Pass of the Mississippi.—The removal of the obstructions at the South Pass of the Mississippi, proceeding from the operations of Capt. Edes, is going on with unexpected rapidity. Already, a direct and navigable channel, from 200 to 400 feet in width, and 24 feet or more in depth, has been formed, reaching nearly two miles; and there remains less than 1000 feet yet in length to be excavated by the force of the current, where the channel is but partially formed, before the *jetty* pass will be open for the largest vessel. The action of the current, produced by the jetties on the bar, was somewhat singular.

The removal of earth has occurred on the up-river side, and has at once attained the extreme depth of 24 to 30 feet, which depth has gradually advanced in a straight line outwards towards the Gulf, until there remains only a crest on the very edge of deep waters, which is now (the last of April) 16 to 17 feet deep. At a short distance outside of the bar, there is a knoll of sand, upon which there was, according to the Coast Survey Reports of 1874, but 11 feet depth of water. This knoll has now (April) been washed away, until 15 feet in depth now exist; and, after this knoll is passed, there is found great depth of water in the Gulf. With the channel once established, years, almost centuries, will be gone before the sediment deposited beyond the present obstructions, will extend itself to form another delta, and the preservation of a permanent channel will depend solely on the maintenance of the heads of the jetties. The new pass has been in constant use for entering and departing vessels for six or seven weeks, and already is more direct and accessible than any other entrance to the river, bidding fair within a month's time, to allow the largest ocean steamer to enter therein. The restoration of the commercial importance of the City of New Orleans is confidently anticipated by its inhabitants as an immediate result from Capt. Edes' undertaking.

Bibliographical Notice.

The New Encyclopedia of Chemistry.—J. Lippincott and Co., Publishers, Philadelphia. 1876. Issued in 40 parts (10 already out), at 50 cents each.

This work is, in reality, a new and improved edition of Muspratt's "Chemistry as applied to the Arts and Manufactures," with many additions relative to more recent applications and improvements of practice during the past thirty years, completely revised in notation to correspond to the modern chemical nomenclature. Possessing all the excellence of arrangement of Muspratt's book, based upon the actual practice which he had so fully collected, the additions on the one hand, and the substitutions on the other, have been so well made, that the best compendium of applied chemistry in the English language has been prepared and offered to the readers of this encylclopedia. The complete work will be over 1000 pages of royal quarto size, in double column print, in clear and distinct typography, and upon the finest of paper. The profuse illustrations of the original work have been added too, and numerous steel plate engravings of apparatus in use, give a higher value to the whole for the practical man. No technical work of the order of merit of this one has before been offered at so low a price; and, as Muspratt's Chemistry already forms a part of the library of every manufacturer, this publication will now be found to be an indispensable substitute.

Civil and Mechanical Engineering.

DEEP-SEA TELEGRAPH CABLES: HOW THEY ARE TESTED.*

The "testing" of a telegraph cable, whether long or short, proceeds upon the principle that the materials offer to the electrical current a resistance: the testing of a cable is the measurement of this resistance. In any cable there are two kinds of these resistance measurements: one of the resistance which opposes the current in its progress along the conducting wire, the other of that which opposes its lateral dispersion. The conductor-resistance is technically termed the copper-resistance, and is extremely small compared with the other resistance. The lateral resistance to the escape of the current opposed by the insulating substance which surrounds the copper-conductor is technically termed the insulation-resistance. Where the resistance to the direct propagation of the electric current through a conducting wire is represented in units, the resistance to lateral dispersion through the insulator will be represented by hundreds, or even thousands of millions, of these units. A third property is that known as the electro-static, or inductive capacity, or simply "charge" † of the cable; in other words, that measured quantity of electricity which the given cable will take up in a given time. So much for the necessary explanation of technical terms.

The copper-resistance (1), the insulation-resistance (2), and the "capacity" (3) are the three points to be ascertained in the testing of a cable; and it is useful to inquire why these are the points to be ascertained.

The chief commercial requisite in any cable, and upon which depends its value to its owners, is the speed with which signals can be transmitted. Speeds depends directly upon two of the foregoing points (that is upon the copper-resistance and "capacity"), and indirectly upon the insulation-resistance. Popular assumption is very much given to the idea that the electrical worth of a cable increases

* From *Nature*, London, April 27, 1876.

† "Capacity" and "charge" are not equivalent terms, although they are so considered in this article to prevent confusion, by the general reader, with the ordinary meaning of the word "capacity." The capacity of a cable remains constant, while the charge varies with the battery power employed.

with its insulation-resistance; as usual with popular notions this is only half-truth. That the cost of a cable follows the ratio may or may not be, but it is certain that above a definite limit the thickness of the insulating coating has no effect upon the practical working condition of the cable. It may be that minor indirect benefits arise, but with these, under the present consideration of the practical testing of a cable, we have nothing to do. A certain standard of insulation-resistance attained, there remain the two points, first, of the resistance offered by the copper-wire; secondly, of the charge. Now it is collaterally to be understood that, as there can be obtained through a pipe a greater flow of liquid when the pipe offers little resistance to the flow, so through the conductor of a cable can a greater flow be obtained when the conductor has low resistance. With most of the Atlantic cables, each nautical mile of the conductor has a resistance equal to that of three to four of the arbitrary units selected by the profession for comparison. There are in use two units of electrical resistance, namely, that determined by a committee of the British Association and the Siemens' unit. These units are very nearly of the same value, one Siemens' mercury unit (the resistance offered by a column of pure mercury of one metre length and one square millimetre section at 0° C.) being equal to 0·9536 of an Ohm,* the technical term for a British Association unit. There is, then, to be considered an electrical length as well as an absolute (or ordinary) length; the proportion that one bears to the other being known, the measures are convertible. Vague as may appear to the reader, this idea of electrical resistance; when he knows that two lengths of a copper wire of given diameter or weight, offer twice the resistance of one, he is as learned as the most skilled electrician, who virtually knows no more.

The consideration of the electrical capacity of a cable is more difficult. While the two other points relate to mass, the question of capacity involves that of surface, and of a property of the insulating material of the cable known as its "specific inductive capacity." The material with which long telegraph cables are insulated is gutta-percha. Two different cables may be insulated with this material to precisely the same dimensions, both as regards the thickness of the

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*Many other standards of measurement of resistance were advocated, and the British association attempted to compare them, and in so doing, adopted a value (which was denominated an "Ohm," in honor of Prof. Ohm, of Nuremburg, who first propounded the theory of measurement of electrical resistance). The value of an "Ohm" is best understood from the comparison to a Siemens' unit, as in the text.

insulator and the thickness of the copper wire, but the "charge" taken by these cables may be very different, and the difference will be due to difference in the specific facilities offered by the two gutta-perchas to induction. This difference between various kinds of gutta-percha is as inherent as is the difference between resistances to conduction offered by different metallic alloys, and is probably very often due to want of homogeneity of the substance. It is by judicious selection and careful manipulation that the cable manufacturer is enabled to maintain a certain standard for any particular cable in question. Capacity, however, not only varies with the insulating material, but it also varies with the amount of surface of the conductor. It is different with different thicknesses of insulating material, but in this respect, after a certain limit has been passed, the decrease in capacity is very small for very large increase in the thickness of the insulating material.

High charge is incompatible with high speed. That cable will, other conditions the same, have the greatest speed in which the charge, or the fraction of the charge to be altered at each signal, is least. Professional necessity has given rise to a unit of quantity of electricity termed a "farad," of which the "micro-farad" is the millionth part. The capacity of a telegraph-cable generally ranges from three- to four-tenths of a micro-farad per nautical mile.

The object of testing a cable is, then, to ascertain whether the insulation reaches the amount specified, and whether the conductor-resistance and the charge are of the required minimum. As these tests are each applied separately to the cable, their consideration will fall under the several heads. It would clearly be impossible within the limits of this paper to describe the many methods which have from time to time been proposed and in use for the testing of telegraph cables. The first methods of testing submarine lines are undoubtedly due to Dr. Werner Siemens and Dr. C. William Siemens, who early in the history of submarine telegraphy communicated their researches on the subject to the British Association at the Oxford meeting of 1860. The principle of these early methods still remains the principle of the methods employed by Sir W. Thomson in his testing of the Direct United States Cable at Ballinskelligs Bay Station in September, 1875, and upon which he has reported to the manufacturers of the cable, Messrs. Siemens Brothers. It is the purport of this paper to describe these tests and the results obtained.

To those who may be unacquainted with the route of the Direct United States cable, it will be necessary to explain that the course taken is from Ballinskelligs Bay, on the west coast of Ireland, to Torbay, in Nova Scotia, whence it again passes to Rye Beach, in New Hampshire, America.

The construction of the cable, which was decided upon by the company acting under the advice of Dr. William Siemens, their scientific consultant, is as follows:—The cable from Ireland to Nova Scotia consists of a conductor formed of a strand of twelve copper wires weighing 400 lbs. per nautical mile. This conductor is surrounded with four coatings of gutta-percha and gutta-percha-compound weighing 360 lbs. per nautical mile, so that the total weight of the "core," as it is technically termed, is 760 lbs. per knot. It was specified that the core should have an insulation resistance per nautical mile equal to 160 millions of mercury units; tests, however, checked and taken under the direction of Mr. von Chauvin, the manager and electrician to the Company, show that no length of core was passed that did not insulate to nearly double this extent, or to 300 million units per knot, the tests being taken after twenty-four hours' immersion of the core in water at 75° F. The "core" is "served" or enveloped in jute yarn, and is then sheathed or covered with iron wires of a diameter best suited to the position of the cable. Thus for the deep-sea, 1,630 knots of the cable are sheathed with ten strands of wire and hemp, each strand consisting of a homogeneous iron wire surrounded with five strands of Manilla hemp, each strand being passed through a compound of pitch, tar, and india-rubber. Each of the iron wires has an average breaking strain of 53 tons per square inch, and is of 0·099 inch diameter. The cable termed medium cable is sheathed with fifteen wires of 0·148 inch diameter with proper sewings of yarn, while for the shore ends, where there is considered to be more friction or wear, this medium cable is again surrounded with iron sheathings of twelve strands of iron wires, each strand consisting of three iron wires of 0·230 of an inch diameter.

The cable from Nova Scotia to New Hampshire consists of a strand conductor of seven copper wires weighing 107 lbs. per knot, covered with three coatings of gutta-percha and compound weighing 150 lbs. per knot, and is also sheathed with iron wires.

The non-electrical reader who may choose to wade through detail that must be somewhat technical will perhaps find help in considering the conducting wire as representing a line of flow or force, such that

if two of these lines be directed into a galvanometer or current-measurer in opposite directions, that having the greatest head or greatest force will preponderate, while no indication will be found on the instrument when the forces are equal; also that from a known force giving through a known resistance a certain instrumental measure, any unknown resistance may be reduced when its instrumental measure is ascertained.

Testing the Resistance of the Copper Conductor.—Electrical measurements upon a long submerged cable differ from measurements made in the laboratory as described in text-books in one very important particular—that of earth-currents. Earth-currents are the *bête-noir* of the electrician, who not infrequently finds them so far masters of the field that his chance of obtaining accurate measures is a poor one. Fortunately, earth-currents do not have so much influence upon the working of a cable as they have upon the testing, and more fortunately still these currents do not always exist, so it is possible to obtain measures during a tranquil period. On the Direct United States Cable, Sir William Thomson found these currents to be equal in value at a period of greatest strength to that from about eighteen cells of the testing-battery—the Irish end being positive generally to the Nova Scotian end. Under such conditions, Sir W. Thomson employed the simple deflection-method of measuring the conductor-resistance, which he takes to be "the only proper method for measuring copper-resistance in a submerged cable." In the following description of the method and its results, it will be seen that the method consists in applying together with a measuring instrument an electric force which yields a certain measure through the unknown resistance of the cable; a known resistance (7300 units) is then substituted for the resistance of the cable, and the latter determined by proportion. The principle of this method is applicable not only to the measurement of the copper-resistance, but is that also of the ordinary method of measuring insulation-resistance, a higher known resistance being used in order more readily to effect comparison with the unknown and much greater insulation-resistance. The actual operation during the period of testing is thus described:—

"The insulation-galvanometer quickened three- or four-fold by a magnetic adjustment, and, with a shunt of twenty Siemens' units on its coil, was put in circuit between line, battery, and earth, and the deflection was observed and recorded every ten seconds. As was to

be expected, large and rapid variations of the deflections were continually taking place on account of earth-currents. The direction of the earth-current was from east to west the whole time, as was shown by the 'copper' current being always greater, and the 'zinc' current less, than the true mean concluded from the observations. It increased gradually (but with some slight backward pulsation) from the beginning—when its amount was that due to a difference of potentials between the Ballinskelligs and Torbay earths equal to 1·7 of a cell—till the end, when it was more than five times as strong, and corresponded to nine cells; the Irish earth positive relatively to the Nova Scotian earth the whole time. To measure the copper-resistance a time of comparative tranquillity was chosen, a reading taken, and then as quickly as possible the galvano-meter short-circuited, the battery reversed, the galvano-meter circuit reopened, and a fresh reading taken. Half the space traveled by the spot of light from the first reading to the second is taken, as being the deflection which would be produced by the battery applied in either direction were there no earth-currents. This was done seven times, and the half ranges were as follows :—235, 231, 229½, 234½, 231, 235, 230—mean 232·3. I found that the same battery applied in the two directions through the galvanometer, and 7,300 Siemens' units gave 232 divisions on one side of zero, and 233 on the other—mean 232·5. Hence the copper-resistance to be inferred from the observations is—

$$7300 \times \frac{232 \cdot 5}{232 \cdot 3}, \text{ or } 7306 \text{ Siemens' units."}$$

As the cable in question is 2,420 nautical miles in length, we have $\frac{7306}{2420} = 3 \cdot 02$ Siemens' units per knot.

Insulation Test.—The ordinary method of testing the insulation-resistance of a cable consists, as has been said, in obtaining upon the galvanometer or measuring instrument a certain measure with a known resistance, and a measure with the unknown resistance, the electric force being constant during the two measurements. From these two measures the unknown resistance is determined. If, for instance, it is known that with a certain battery power and a resistance of 100,000 units we have a deflection-measure of 100, it is deduced, when with an unknown resistance and the same battery power the deflection of 50 is obtained, that the resistance must be twice as great (namely 200,000), since the observed effect is halved. This system is

that generally pursued, but, like the other measurements upon submerged cables, comes under the effect of earth-currents ; and to meet this contingency Sir William Thomson has arranged a new method, bearing upon the principle that the insulation of a cable may be determined from the proportion of loss (during a given time) of electric power that has been imparted to it. In the following description it will be seen that this loss is measured by the deflection due to the current entering the cable to make up the loss, and this deflection is compared with another deflection obtained by altering suddenly by a small quantity the battery power employed. The latter deflection being a measure of a known force or potential, the other measure for lost potential is determined, and consequently the loss of potential known.

"The cable being offered to me again from midnight till 2 A.M. on the 17th, I made," says Sir W. Thomson, "another series of tests at that time for the main object of measuring the insulation-resistance. I found the line in a much less disturbed state, and was able to make a perfectly satisfactory insulation test by the ordinary galvanometer method. I applied, however, also a new method, which (no electrometer being available) I had planned to meet the contingency of the line being disturbed by earth currents so much as to render the ordinary test unsatisfactory, but not so much as to vitiate an electrometer-test. This method, which I think may be found generally useful for testing submerged cables when an electrometer is not available, is as follows :—1. Apply the ordinary test by battery and galvanometer for a certain time. 2. Insulate the cable for a certain time and then shunt the galvanometer to prepare for No. 3 (unless you have conveniently available a second galvanometer suitable for discharges). 3. Instantaneously reapply the battery, through the insulation galvanometer properly shunted (or a special discharge galvanometer), to the cable, and observe the maximum of the sudden deflection produced. 4. Go on repeating Nos. 1, 2, and 3 as long as you think proper, according to circumstances. 5. To determine the proper ballistic constant of the galvanometer for utilizing the observed result of No. 3, find the maximum of the sudden deflection which takes place when a sudden change of electrification is produced by instantaneously changing by a small measured difference the potential of one electrode of the galvanometer, the other electrode being in connection with the cable. 6. The change of potential which, in the

operation of No. 5, would give the same deflection as that observed in No. 3, is equal to the change of potential which the conductor of the cable has experienced during the time when it was left insulated according to No. 2. Hence calculate the insulation-resistance in ohms or megohms* as in the ordinary electrometer method when the electrostatic capacity of the cable is known."

In carrying out this test, the 20-cell insulation battery (with its poles joined through 20,000 Siemens' units) was applied, zinc to cable, through the insulation galvanometer with a shunt of 5,000 Siemens' units on it. Then, the galvanometer indication was read and recorded every ten seconds for three and a half minutes, when the cable was insulated during a minute according to No. 2 of the directions above, and a shunt of 30 substituted for the 5,000. At the end of the minute the battery was instantaneously reapplied, the throw of the galvanometer observed according to No. 3 and the shunt of 30 removed, and 5,000 reapplied. The cable was again insulated for a minute, the galvanometer shunted with 50 (instead of 30 used the first time), and the operation of No. 3 repeated. The proper ballistic constant of the galvanometer was determined by applying alternately full power and $\frac{49}{50}$ of full power of the insulation battery; the change from one power to the other being made in each case as instantaneously as possible. Twelve galvanometer readings taken at ten seconds' intervals during the second and third minutes of the electrification gave for mean deflection 127, and the readings taken from the fourth to the twenty-fourth minutes gave for mean deflection 82·1. The sensibility of the galvanometer in the condition in which it was used for these readings was such that a deflection of 290 would have been given by the actual battery, with a resistance of 1,000,000 Siemens' units. Hence the insulation-resistances proved by the mean observed deflections were for the deflection, 127 from the second and third minutes 2,280,000 Siemens units, and for the mean deflection 82·1 from the fourth to twenty-fourth minutes 3,540,000 units. The new method described gave, as the mean of the observed ballistic deflections or "throws," the number 89 8, or say 90. The ballistic deflection due to instantaneously changing the potential by $\frac{1}{40}$ of that of the insulation battery, in accordance with the rule of one to five above, was found to be 112 divisions. This is $1\frac{1}{4}$ times the preceding mean throw (90), which therefore showed a change of potential equal to $\frac{1}{50}$ of that of the

* A megohm equals a million ohms.

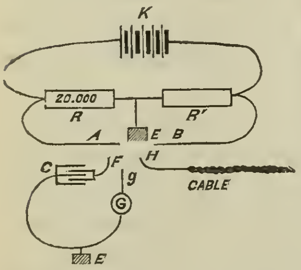
battery. Hence the mean fall of potential was $\frac{1}{40}$ during the minute, or at the rate of $\frac{1}{3000}$ per second. The capacity of the cable (measured in the way presently described) had been found to be 991 microfarads. Hence the insulation-resistance is $\frac{3000}{991}$, or 3·027 megohms, or 3,170,000 Siemens' units, corresponding to the 3,540,000 units given by the ordinary method. With copper to line, a fresh series of tests gave 3,520,000 megohms, or 3,690,000 Siemens' units.

In the reduction of the insulation-resistance of the whole cable to its insulation-resistance per knot, it has to be observed that as the insulation of the cable is inversely as its length, one knot of the cable will give an insulation resistance equal to that of the whole cable multiplied by the number of knots' length in the whole cable.

Measurement of "*Capacity.*"—Just as the chemist has his vessels for measuring out quantities of liquid, so has the electrician his special arrangements for measuring out quantities of electricity; but there the analogy ends, for while the measure of the liquid is direct and visible, the electrician infers his measured quantity generally by the mechanical work effected on the index of the measuring instrument, or by the absence of such work. The apparatus used in practice for measuring quantities of electricity is termed a "condenser." "Condensers" are constructed having any required capacity, and if such a condenser of which the capacity is known is charged from a battery, then discharged through the measuring instrument, and the deflection produced noted, it is only required to charge from the same battery the cable or any other condenser of which the capacity is to be measured, then to note this discharge deflection, and by proportion to deduce the unknown capacity. On short lenghts of cable this procedure is actually adopted, but on long lengths it becomes liable to error, chiefly from the fact that as with long lengths some perceptible time is required to discharge the cable, the ballistic throw or sudden deflection produced upon the measuring instrument by the rush of electricity from the cable does not measure all that passes out. It is consequently necessary to devise some method like the following used by Sir W. Thomson, in which the charge from the cable (communicated thereto by a different battery power to that charging the condenser, but the relative powers being known) is neutralized by a charge of opposite electricity from the condenser, and the neutralization declared by the non-production of movement in the measuring instrument.

The following diagram, which is not, however, taken from the report, will explain the method:—

K, battery of 80 cells, well insulated; R, resistance of 20,000 units; R′, variable resistance; C, condenser of 80 microfarads' capacity; G, shunted galvanometer; E, earth.



The condenser is electrified by bringing F and A into contact, and the cable by making contact between H and B, for sufficiently long time to fully charge the cable. These contacts are then broken, and instantly after, contact made between F and H. This contact is maintained for five to ten seconds, when the additional contact with *g* is made. The variable resistance is adjusted till this last contact produces no movement on the measuring instrument.

It was found that when the cable and condenser were charged to opposite potentials in the proportion of 1,615 to 20,000 no throw occurred, whence the deduction that the capacity of the cable was

$$\frac{20000}{1615} \times 80 \text{ microfarads, or}$$

991 microfarads, and the length of the cable being 2,420 knots, this was equal to 0·409 of a microfarad per knot.

In concluding the report upon the electrical conditions of the Direct United States Cable, Sir William Thomson remarks: "I am glad to be able to say that my test proved the cable to be in perfect condition as to insulation, and showed its electrostatic capacity and copper resistance to be so small as to give it a power of transmitting messages, which, for a transatlantic cable of so great a length, is a very remarkable as well as valuable achievement." This article would be exceeding its purpose if it were to include inquiry into the present position of Atlantic Telegraphy; but it is a mark of great progress in electrical engineering and cable manufacture that a cable of such length as 2,420 miles can be delivered up to the company working it in a *perfect* electrical condition. This has not been the case in earlier transatlantic attempts; and some idea may be formed by the general reader of the care required to bring about this end, when it is known that a small hole, smaller in size than the finest pin-hole, in any portion of the two thousand miles length of gutta-percha covering would render the electrical conditions of the cable imperfect.

Climbing a Standpipe.—Some reparations having become necessary upon the standpipe at Spring Garden Station of the Philadelphia Water Works, amongst which the scraping and painting of the exterior, which had become weather worn and rusted, was the most considerable task, the first step to be taken was obviously to construct a scaffold for the workmen; and, as no means had been provided for the attachment at the top of the pipe of the blocks and falls from which a scaffold should be suspended, the climbing of the pipe for this purpose was an undertaking which preceded all others.

This climbing was accomplished by Mr. George Robinson (a working rigger of this city) in the following way:—

The standpipe itself is 127 feet of wrought iron shaft, above a square stone plinth, the shaft being about 6 feet in diameter at the bottom, and $4\frac{1}{2}$ feet in diameter at the top (under the cap, or head, ornament, which projects 12 or 16 inches all round).

At the foot of the plinth, a light ladder, 30 feet long, was set up, with the top to rest against the shaft. Climbing the ladder to the top, carrying a bow or ring of $\frac{1}{2}$ inch round iron rod, which was made to surround the shaft loosely, with the ends about 16 inches long, turned downwards, these ends were lashed fast to each side of the ladder. Next, a piece of rope (3 inch = 1 inch diameter), with an eye in one end, was passed also around the shaft, and was lifted to the top of the ladder, below the ring of iron, when the plain end of the rope was drawn through the eye and made fast, so that the rope formed a "lashing," and encompassed the shaft tightly. A single block was now hooked on to this lashing, and the end of the fall passed down between the ladder and the shaft, was made fast to the lower round of the ladder, and the ladder itself then hauled up to the lashing; and with its upper end steadied by the ring of iron, was placed vertically against the side of the shaft. Another ring of $\frac{1}{2}$ inch iron was placed around the shaft at the bottom of the ladder, which ring was also lashed to the sides of the ladder, and steadied the bottom whenever it was attempted to lift by the lower round. The ladder being elevated as described, and held in place by making the hauling side of the fall fast to something below, another lashing like the first one, was taken to the top of the ladder (in point of fact, Robinson stood upon the top of the ladder each time it was hauled up, and took with him this second rope); and this rope was then converted into a second lashing like the first one, only about 25 feet higher up on the shaft.

A second block was hooked into this second lashing, and the end of a fall from it was taken down behind the ladder to the lower round, and made fast, while the other end was hauled tight to relieve fall number one. Lashing number one was now cast off, and taken to the top of the ladder, and by means of the second fall the ladder, with Robinson upon it, was lifted to the second lashing. At this point, the operation merely repeated itself, except that, from the reduced diameter of the shaft, it was necessary to bring the head of the ladder up to the lashing and make new ends, to the top bow of iron (which could be bent cold) twice in the whole climbing. The bottom ring it was not found necessary to reduce in dimension. Five fleats brought Robinson to the top of the shaft, and as the top of the ladder was then hung far enough from it, he was able to pass at once over the projection of the cap, and mount upon the plates which covered this projection (a low ornamental railing surrounds the cap). Having reached the top, the other attachments became easy. The man Robinson, and another rigger to handle the rope, aided by one or two men, when a pull was required, performed alone all the labors of the task. They came to the Spring Garden Works at about 10 A.M.; and in less than two hours (before 12 M.) the column had been climbed, and the ladder was sent down.

Chemical Nomenclature.—A remarkable paper upon this subject by Prof. Henry Wurtz, appears in the March number of the *American Chemist.* Prof. Wurtz enunciates a theory of molecular volumes which he applies to numerous examples, and exhibits the results. The basis of the theory is, first, that there is a constant temperature of nature, which is normal for all substances, and is about —1° centigrade, and at this temperature all molecules will have diameters, which will refer to a molecular diameter for ice of 2·7, expressed in even tenths for multiples. While it cannot be said that Prof. Wurtz's results possess all the simplicity of expression or application which might be desired, yet the direction of the inquiry is highly instructive; and without expecting the even numbers as a result, it is very possible that some *law* of variation of temperatures for various chemical bodies, may allow definite relative volumes to be established with as much certainty as the atomic combinations.

Note.—A very valuable article upon the Determination of Strains in Continuous Girders, by Prof. A. Jay DuBois, is unavoidably deferred until the July number of the JOURNAL.

Errata.—Please correct in article of Prof. Du Bois on Roof Strains, page 243, lines 14-15:—For 525, read 461; and for 437·5, read 341.

Chemistry, Physics, Technology, etc.

"THE PHYSICS OF THE ETHER."*

By William B. Taylor, Washington, D.C.

Bold speculation, based upon judicious induction, and conscientiously brought to the earliest available test of phenomenal accordance, is undoubtedly the means, and the occasion of scientific advancement. If ever the great mystery of force, or of matter, is to be unveiled, it will be by this process; and the very frequent, though somewhat supercilious disdain of speculation or "hypothesis"—whether by the positivist on the one side, or the teleologist on the other,—is neither based on the caution of scientific fealty, nor justified by the teachings of intelligent experience. The human tendency to form guesses, however, is unfortunately vastly in excess of the tendency to make careful comparisons of observation. The first is exceedingly easy,—the latter, often tedious and laborious, requiring patient vigilance and generally skilled training. And a necessary result of the rapid prevalence of the scientific method over the metaphysical in modern times, has been to relegate to a lower and less disciplined order of intellect, the crude and unfashioned vagaries which two or three centuries ago so prominently characterized the leaders of "philosophy."

The work before us, extending to 136 octavo pages, is written with much diffuseness, and with frequently recurring repetitions of statement; as though its 25 chapters or "sections" had been produced at irregular intervals, and had been collected from various sources of publication. Its author belongs to a not inconsiderable class of students and thinkers, whose activity of imagination, unbalanced by an equal inertia of solid logic, leads them to find in "motion" a sufficient explanation of all the phenomena of *attraction* or *repulsion*. Like others of his class he is puzzled by—and cannot "comprehend" action at a distance; therefore he is clear that it must be a fallacy.

* Physics of the Ether. By S. Tolver Preston. London, E. & F. N. Spon, 1875.

The modern dynamical theory of gases,* in which the temperature represents simply the amount of molecular motion at any moment existing in the given volume, is too enticing an apparent analogy, not to have been very often pressed as a type of all energy. And hence the inter-stellar medium or vehicle of radiant light and heat, is made to do duty for a vast number of very incongruous effects.

"As a first condition, we require the existence of a physical agent capable of transmitting motions to a distance with speed and facility, in order to refer to physical agency all the effects at present brought under the theory of 'action at a distance.' As a second condition, this physical agent must be shown to be capable of enclosing a store of motion of a very intense character, competent to produce all those forcible molecular and other movements of matter, exhibited in such effects as the phenomena of chemical action, the 'electric' motions, combustion, the remarkable development of molecular motion observed in the case of explosive compounds, such as in the explosion of gunpowder, and other numerous and striking phases of motion witnessed on all sides. Thirdly, this physical agent will have to be proved to be competent to exert an intense pressure upon the molecules of matter, as consonant with the very forcible character of the static effects exhibited in 'cohesion,' and the stable aggregation of molecules generally." (*Physics of the Ether*, p. 10.)

Such is the programme offered, as the alchemy of the universal solvent of *force.*

"The quality of elasticity in an aeriform medium, by which it can expand and fill a larger portion of space than it occupies under normal conditions, and in which act motion is developed, must be dependent on a motion previously existing. Hence since it is an observed fact that the ether possesses in its normal state the quality of elasticity, the inference necessarily follows that the normal state of the ether particles must be a state of motion," (p. 12). "To summarize therefore: the inferences are, first, that the normal state of the component particles of the ether is a state of motion; second,

* "The greatest achievement yet made in molecular theory of the properties of matter, is the kinetic theory of gases, shadowed forth by Lucretius, definitely stated by Daniel Bernoulli, largely developed by Herapath, made a reality by Joule, and worked out to its present advanced state by Clausius and Maxwell." Sir Wm. Thomson's Address to the British Association in 1871. (*Report B.A.*, vol. xli, p. 93.)

that this motion of the particles takes place in straight lines; and third, that this motion takes place towards every possible direction," (p. 14).

But here a very formidable difficulty is at once encountered. How is this inevitable "elasticity" of ether to be evolved from "motion"? Two colliding atoms of the ether, are either deformed, or not deformed by their contact. If not deformed, there can of course be no recoil: and there is simply the loss of the entire *vis viva*. If deformed, they either continue so, without further effect, or they regain their original form with a resilient force which is ordinarily designated as "elasticity." What is this resilient force? Alas, the keenest human wit has hitherto been able to give no other answer, than to accept the observed fact as an *ultimate* one, and to call it by its most obvious character, "repulsion." The conception is of course not essentially changed, if we suppose the atom perfectly hard. and the resilience exerted by an aura of repulsion.*

Here then at the very outset of the purely *rational* system of universal kinematics, the disciple of Motion is brought face to face with the dreaded phantom of an occult property,—the "incomprehensible" *static* force—"repulsion." Nor is there any escape, however resolutely the disciple may close his eyes to the catastrophe. Without the conserving and restoring spring of elasticity, the machinery of force (as well as of motion) is forever at a stand-still.

Mr. Preston first attacks the problem of cohesion.

"Steel of the best quality. in the form of fine wire, has been known to bear a tensile strain represented by not less than 150 tons per square inch, and even this cannot be said to be the limit to the tensile strength of steel, since the tenacity obtainable increases as the diameter of the wire is reduced," (p. 16).

But must not the bond of "chemical affinity" be sometimes even stronger than this?

"If we suppose the intensity of the pressure to be overcome in the case of the separation of the molecules of oxygen and hydrogen

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* An ingenious attempt has been made to explain elasticity kinetically by assuming that the ultimate atoms, instead of being deflected by collision, revolve in orbits of extreme eccentricity, whose outward excursions represent the repellant force. But 1st, such revolving atoms must transmit their entire centrifugal force at the first impact with external particles, remaining inert forever afterwards: and 2d. their original orbital motions could have been attained only by the coercion of an *attractive* force.

one of the most powerful cases of chemical union, to be only three times greater than that overcome by the separation of the molecules in the example given of the steel wire, then this would give 450 tons per square inch as the difference of pressure effective in the case of the molecules of oxygen and hydrogen. This is, however, not the total or normal ether pressure, but only the effective *difference* of pressure; however, as our object is only to arrive at a limiting estimate for this pressure, or to fix upon the lowest value consistent with what observed physical facts would require, we will accordingly take in round numbers, the estimate of 500 tons per square inch, as a limiting value for the ether pressure; having thus valid grounds for concluding that this estimate is within the facts as they actually exist." (p. 18).

Now we have what may be called the modulus of mobility of the ether, expressed in the velocity of light,—185 thousand miles per second. "The normal velocity of the ether particles must at least equal that with which they can transmit a wave;" and cannot probably be many times in excess of this. Mr. Preston's method of arriving at the *density* of the ether, is as follows: Supposing that the average velocity of aerial particles at ordinary temperature be taken at 1,600 feet per second, producing a dynamic pressure of 15 pounds per square inch, then since dynamic pressures are as the velocities squared, the number of times that the square velocity of air (in feet per second) is contained in the square velocity of luminiferous ether (in feet per second) may be taken as the number of times the mass or density of air exceeds that of ether. This would be about 390 thousand million times, (p. 20).* This, however, is

* Sir John Herschel, from the squares of the velocities of light and of sound, has estimated that the elastic force of ether "in proportion to the inertia of its molecules" is about one billion times that of air; and accordingly to compress the ether to a density equal to that of ordinary air (at 15 pounds to the square inch) would require a pressure of some 15 billion pounds (6,700 million tons) to the square inch. *Familiar Lectures*, 1866. Lect. vii, "On Light," sect. 65.) But as the velocity of wave transmission is not only as the square root of the elasticity of the medium directly, but *inversely* as the square root of its density, it is evident that the above estimate, based exclusively on elasticity, must be very much too high: for if the rarity of the ether were a million times greater than that of air, then this alone would give a thousand fold greater velocity to light than sound, leaving but a million fold excess of elasticity.

Mazotti has computed that a density of ether, equal to one 360,000 millionth of

giving the ether only the same dynamic pressure as the atmosphere. But the pressure previously assumed for the ether, is 500 *tons* per square inch, which is 74,666 times the ordinary atmospheric pressure; and hence the ether must be this many times *denser* than the above estimate; or its rarity must be reduced to only a little over 5 million times the rarity of ordinary air, (p. 20).

Now these *data* being admitted, how is the dynamic pressure of an ether so constituted, supposed to act, in order to hold so firmly together the molecules of steel, while having free access to all sides of each molecule? Mr. Preston here builds entirely on the sandy foundation of Mr. Guthrie's experiments with vibrating tuning-forks, detailed in the Philosophical Magazine for Nov., 1870, (vol. xl., p. 345,) in which suspended pieces of paper, and other light objects, were observed to approach the vibrating body; and with a rate proportioned to the amplitude or energy of the vibration. Counting from the absolute zero, Mr. Preston estimates that the thermal energy of vibration of the molecules of steel, at 60° F., is equivalent to that of a fall through about 7½ miles, corresponding to a velocity of 1,600 feet per second, (p. 31). The vibrating molecule then is the "motor" which is to simulate Mr. Guthrie's tuning-fork in producing approach by another body.

"If the question be fairly examined into, there exists no other conceivable process by which one mass or molecule of matter could move or act upon another mass or molecule placed at a distance, than by means of vibration. For in the first place, in order for a mass of matter to be capable of moving or physically affecting a

that of mean or ordinary air, would account for the observed acceleration or diminution of period of Encke's comet. (Mrs. Somerville's *Mechanism of the Heavens*, book iii, chap. 6.) Mr. Harkness of the Naval Observatory at Washington, however, estimates that the resistance of Encke's comet would be explained by a rarity of ether, exceeding Mazotti's result by about 144,000 times; or about 52,000 billion times the rarity of the ordinary atmosphere. (*Washington Observations.* Report of Mr. Wm. Harkness on Encke's comet in 1871.)

It is proper to add, however, that Encke's hypothesis of a *resisting* medium in space (so generally accepted) is by no means established, or even rendered probable, by the isolated case of a single cometary retardation: which, as Mr. Asaph Hall, of the Washington Naval Observatory, has well shown, is susceptible of quite a different interpretation. (*Am. Journal of Science*, 1871, vol. ii, p. 404.)

second mass placed at a distance, without approaching it, the mass must have a motion of some kind, so as to be capable of disturbing the surrounding medium which forms the only physical connection between the masses; secondly, since the mass or molecule in acting upon the second molecule maintains a fixed position, it follows that the motion of the molecule must take place in such a way that the molecule can maintain a fixed position, and nevertheless can disturb the surrounding medium. Now a vibratory motion of the molecule constitutes the only conceivable means of satisfying these conditions, as by this form of motion, the molecule can retain a fixed position by oscillating about a fixed point, and yet can disturb the surrounding medium by its motion. Hence in a mechanical point of view, nothing can be more obvious or to the purpose than the vibratory motion of matter so constantly presenting itself in physical phenomena," (p. 33).

Surely,—" nothing can be more obvious!" But a little difficulty again suggests itself.

"A molecule of matter surrounded by the ether cannot possibly be in motion without disturbing the ether, and thereby giving up or dissipating continually its motion in the surrounding ether," (p. 33).

The tuning-fork expending its motion on the resisting air in order to produce a mechanical effect on the suspended card, could not continue its vibrations a single minute, did not Mr. Guthrie stand by with his violin-bow to excite the motion. But where is the "prime motor" to fiddle the molecule into continued activity?

"Since, therefore, the motion of matter is being continually dissipated in the ether, the ether constitutes the *receptacle* of all the motions of matter. The ether, therefore, must in accordance with the principle of conservation, be the *source* of all the motions of matter; for matter cannot evolve motion out of itself. Also, since matter cannot retain its motion, but must be always dependent on the ether for any supply of motion, matter therefore cannot in any case constitute a *source* of motion. The ether therefore constitutes both the source and the receptacle of all the motions of matter," (p. 90).

Here then in this vicious "cyclical process" of perpetual motion, we have the notable secret of cohesive attraction. The all-moving ether stimulates the molecules of matter into an activity, which, re-

acting upon the ether, produces therein waves of fresh energy so exuberant, that the ever-dancing molecules are kinetically bound together in bonds of—literal *steel*! And thus blindly pursuing the analogy of gaseous thermo-dynamics, as the writer fondly imagines, he reaches his goal—with the *dynamics* quite omitted. According to the doctrine of correlation and conservation of force, as based on the inductions of experimental observation, the continuity of thermal impulse on the moving particles of a gaseous medium, is maintained *only* by the fresh impacts resulting from the recoils of minute successive "falls" of material molecules: and to the extent that these "falls" are completed or terminated, must the "working" power of the derivative gaseous motion rapidly decline. By Mr. Preston's pan-kinetic scheme, there is no such action as a fall in nature; there is only propulsion; the propeller being always ultimately the thing propelled.

After this general exposition of the "cyclical process," it might seem hardly necessary to follow in detail the method by which this wonderful bond of vibration is supposed to be effected.

"If we suppose the imaginary case of a vibrating molecule of matter completely isolated, then stationary vibrations could not be formed in the medium, the equilibrium of pressure of the medium about the molecule could not be disturbed, and the molecule would be in equilibrium. But if we suppose a second molecule is placed in proximity, then the medium about the molecule is specially disturbed at that side where the second molecule is situated, due to the formation of stationary vibrations in the medium intervening between the molecules by mutual reflection of the waves; a rarefaction of the intercepted vibrating column of the medium, which abuts against the opposite molecules, being the result. The condition of equilibrium of the molecules will therefore depend upon the fact whether the pressure of the intervening vibrating ether column is greater than, equal to, or less than the ether pressure at the remote sides of the molecules, where the normal ether pressure exists; the molecules being driven in the one direction or in the opposite, or remaining in equilibrium, according to the relation of these two pressures," (p. 44.)

"When the molecules are placed in very close proximity, the intercepted ether column becomes short relatively to its breadth; the lateral area afforded for expansion becomes contracted, and the pul-

sations of the column are more concentrated against the opposing molecules, tending to separate them; also the energy of the stationary vibration of the column has been increased, owing to the increased proximity to the molecules. . . . . On the other hand, when the separating distance of two molecules is increased, the intercepted ether column becomes long relatively to its breadth, more lateral area is afforded for expansion, which would conduce to a rarefaction of the column," (p. 45).

After a suitable amount of expansion of this idea, the author concludes:

"Since a rarefaction of the medium constitutes the only possible physical means by which an 'attraction' (approach) can be produced by vibration, and further, since a rarefaction is only possible under the condition of a stationary vibration of the medium, it therefore follows that a stationary vibration can be the sole physical cause concerned in producing an 'attraction,'" (p. 49), *Q. E. D.*

The same mechanical agency which is thus supposed to be adapted to control material particles within infinitesimal distances, and efficient to hold them there in a stationary equilibrium of enormous tension, is also proposed for the very different and incongruous duty of controlling the same particles at unmeasured distances, in a movable equilibrium, and by a bond which is at once the most instantaneous (if the degree may be allowed) and incomparably the feeblest of all known forces. Newton has shown that two spheres each of one foot diameter, and having the mean specific gravity of the earth (5·5)—"if distant but by one-fourth of an inch, would not even in spaces void of resistance, come together by the force of their mutual attraction, in less than a month's time." (*System of the World.*)

No explanation is attempted of the peculiar nature of etherial vibrations, which, able to maintain a constant differential impulse upon every molecule of two such masses for 30 days, without producing in either ball a motion of more than one-eighth of an inch during all that time, are yet (with the speed of light) infinitely too slow to represent the action between the sun and the earth. We are simply told that

"The vibrations of masses or molecules of matter are in all cases necessarily attended by a rarefaction or displacement of the intervening medium: this conclusion holding, however distant the masses may be from each other, or however feeble the vibrations," (p. 43).

This conclusion, however, is justified by no known laws of physics or of hydrodynamics: and if it were, would still prove utterly inadequate to illustrate the subject. And this crude application of a mistaken dynamic analogy, capable of expressing no one ascertained characteristic of gravitative action, is gravely propounded as a full and exhaustive exposition of celestial mechanics. We are asked to believe in a system of "stationary vibrations" (with an infinity of nodal points) extending through more than 90 million miles, or in the case of the planet Neptune, though considerably beyond 2,000 million miles, though with a constantly changing radius vector, from perihelion to aphelion; while as an etherial vibration requires about four hours to reach Neptune, it is evidently impossible for the line of "impulsion" to be rectilinear. And we are asked to believe that these vibrations will produce a line of "rarefaction" (straight or curved) while the mobile ether is supposed to exert on all sides of this extended line, a dynamic pressure of 500 tons per square inch. What effect on the vibratory column of rarefaction between two distant bodies, the sudden interposition of a third body will have, as in the case of transits and eclipses, we are not informed.

(To be continued.)

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.

From the *Chemical News.*

[Continued from Vol. ci, page 356.]

Being cooled to the temperature of spring water it passes into an expansion piston machine, where it yields power in the same manner as steam. In consequence of the great expansion there is a considerable fall of temperature (see below), sometimes reaching —20° to —30°. The gas as it escapes from the machine can be used for

* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

cooling any article, for producing ice, and, finally, it may serve for the manufacture of soda water. The machine shown at the Exhibition was two horse power. The cost of the gas is said to be quite covered by the value of the copperas produced; 1 cwt. sulphuric acid (costing 5 florins Austrian) and 1 cwt. iron spar (1 florin 50 kreutzers, together 6 florins 50 kreutzers) yielding 240 lbs. copperas (at 3 florins per cwt.), worth 7 florins 20 kreutzers. The idea of this combination is doubtless ingenious, and in individual cases it may prove remunerative in practice, but for general application it is not suitable. One cwt. iron spar yields about 20 kilos. carbonic acid, which, at a pressure of 5 atmospheres, represent 2 cubic metres. On expansion to 1 atmosphere, this quantity can theoretically produce at most a working power of 170,000 kilogrammetres, equal to 1 horse power for about half an hour. By expansion, the gas loses about 200 heat units, and at the outside the same amount is available for the production of ice, yielding not more than 2 kilos. Hence it is plain that exceedingly large quantities of materials are requisite, and that it would be difficult to find a sufficient demand for the copperas. The escaping carbonic acid, also, can be but very partially utilized in the manufacture of soda water, and would require for this purpose to be compressed anew, so that it would appear more advantageous to pass it at once into the water as it issues from the generator.

If the carbonic acid is used for making soda water as it issues from the ice receiver, the absorption would take place at about — 5°, under a pressure of 33 atmospheres, or about six times more than is necessary. The power which the machine must exert to produce this superfluous pressure is totally wasted. The latent vapor heat of carbonic acid is certainly not yet known, but even if it were high (which, from the great specific gravity, is improbable), enormous quantities of carbonic acid would be required to produce only a moderate yield of ice, far larger than there is any prospect of utilizing in the manufacture of effervescing beverages. We can, therefore, prognosticate no success for the above mentioned apparatus, and consider that the use of carbonic acid in a circulatory process would be more rational.

The Ammonia Machine.

At common temperatures ammonia is a gas; under pressure it may be condensed to a liquid. The temperature and pressure of liquid ammonia, accord ing to Regnault, are respectively as follows:

Temp.—	+40°	+20°	0°	—20°	—30°	—40° C.
Pressure.—	15·5	8·5	4·4	1·84	1·16	0·7 atmos.

Ammoniacal gas is readily soluble in water, which at 0° it saturates with 1050 volumes, or 0·875 in weight. At 20° water absorbs 654 vols., or 0·52 of weight, a little more than half its own weight. In this state it forms the liquid ammonia of commerce. The absorption is attended with a considerable rise of temperature, whence the latent heat of ammoniacal gas may be calculated as 500°, or close upon that of steam. The gas absorbed by water can be entirely expelled by the application of heat. A decrease of pressure has the same effect, in which case the temperature falls.

If aqueous ammonia is heated in a closed boiler the expulsion of the gas can be carried on even under a strong pressure. If the gas liberated is conducted into a cooler at a certain temperature it passes the point of saturation and condenses to form liquid ammonia. This liquid anhydrous ammonia if brought in connection with a receiver containing water, rushes into it with violence and is absorbed. In proportion as the solution is heated, the temperature of the evaporating liquid is lowered, and may fall to —50°. On these principles depends the ingenious apparatus constructed by Ferd. Carré. It has two modifications, adapted respectively for the intermittent and for continuous production of ice, the former on a small scale for quantities of 1 and 2 kilos., the latter for manufacturing purposes, and arranged so as to turn out 25 to 200 kilos. hourly. The apparatus is manufactured by Mignon and Rouart, of Paris. The intermittent machine consists simply of two vessels free from air and connected firmly by means of a tube. The weight of the whole is such that it can be conveniently lifted and turned. One of the receivers contains ordinary liquid ammonia, whilst the other is empty. The operation begins by placing the receiver containing ammonia over a charcoal fire, whilst the empty one is set in a tub of cold water. The gas is expelled by the heat and condensed in the cold receiver, forming a liquid. When all the ammonia has passed over, the apparatus is taken up, the receiver which had previously been heated is placed in the tub of cold water, and the substance to be frozen is put in a tin cylinder, fitting into a concavity of the receiver containing the liquefied gas. The latter evaporates, producing a great reduction of temperature, and is again absorbed by the water which has remained in the other receiver.

The continuous apparatus is more complicated. It consists princi-

pally of a vertical cylindrical boiler supported by masonry in which the heating and volatilization of the ammonia for the preparation of liquefied ammonia goes on without interruption. The cylinder consists of two compartments, the lower containing a very dilute solution chiefly deprived of its ammonia, whilst in the upper are a number of bowls, into the uppermost of which flows fresh liquor ammoniæ; the liquid as it overflows enters the next bowl, and so onward. The lower compartment only is exposed to the fire. The very aqueous vapors given off convey as they ascend more and more ammonia into the bowls, which at last evaporates almost, though not absolutely, free from water. The gas now arrives in the cooling apparatus, in which it is condensed to a liquid. The pressure at which this takes place depends on the temperature of the condenser, and varies from 4·4 to 8·5 atmospheres, when the temperature of the water used for cooling ranges from 0° to 20°. The temperature of distillation is about 130°. From here the liquefied ammonia, at the pressure of the boiler, arrives in a regular current in the evaporator (ice-generator), the influx being checked by a regulator. The arrangement of the ice-generator presents nothing worthy of remark. A resolution of chloride of calcium takes up the cold and transfers it to the water to be frozen. If a liquid, *e.g.*, beer-wort, requires merely to be cooled, no intermediate body is requisite. The ammonia evaporating in the cooler has to be absorbed by water. As an absorbent is employed, the liquid in the lower half of the cylinder, which is not quite exhausted and which issues continuously in a thin stream, arrives cooled in the absorption vessel. The latter, again, must now lie in a cooler in order that the high temperature produced by absorption may not hinder the further reception of gas. Thus, therefore, liquor ammoniæ is formed as at first, and is thrown back into the cylinder by means of a pump, exchanging on the way its heat for that of the liquid drawn off from the lower compartment of the cylinder. As the ammonia evaporating in the cylinder is not quite anhydrous, a certain amount of water reaches the ice-generator, where it gradually accumulates and retards evaporation. From time to time, therefore, the contents of the cooler must be drawn off, and pumped direct into the cylinder.

The first intelligence concerning the apparatus here described is contained in a communication by Carré to the Paris Academy, December, 1860. * The inventor's English patent bears the date October 15,

* Carré, *Comptes Rendus*, li, 1023.

1860. Not long after in January, 1861, MM.* Tellier, Budin, and Hausmann, sen., claimed priority in the invention, which they had patented in July, 1860.† For machines on the small scale they recommended at the same time sulphurous acid instead of ammonia, since, though less soluble in water, it requires only half the pressure. The courts of law appear, however, not to have decided the question of priority in favor of these gentlemen, as their name does not occur in connection with the further development of the machine. We find, however, that Tellier, in the year 1862,‡ issued a report in which he recommended ethylamin and methylamin for use on the large scale instead of ammonia. The vapor of the latter is absorbed by water in double the volume of ammonia and possesses a very slight tension, so that the internal pressure in the apparatus scarcely exceeds one atmosphere. Hitherto, however, we do not learn that machines for the application of these substances have come into use. Since Tellier has recently—as we have mentioned above—constructed an air-pump machine for methylic ether, it may be suspected that peculiar difficulties have been found in the utilization of these amines. A detailed description of Carré's continuous machine with illustrations has been published by Pouillet.|| An illustrated account of the small intermittent apparatus may be found in the *Wurtemberg Gewerbeblatt* for 1861, No. 40, and has been copied into other journals.§ In 1868, the author drew up for the *Badener Gewerbezeitung*, a paper on ice machines, based upon experiments undertaken with the small machines then known.

In this essay Carré's small apparatus is described and illustrated by diagrams. The larger, or 2 kilos. size, yielded $2\frac{2}{3}$ kilos. ice with a consumption of $\frac{3}{4}$ kilo. of wood charcoal, the time of heating being 80 minutes, and that of freezing two hours. Ingenious and effective as is this apparatus, it cannot be recommended for household use, as its manipulation requires too much technical skill. In the *Badener Gewerbezeitung* for 1869, followed an account of the machines for manufacturing purposes, in which Carré's large machine is described

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* Tellier, Budin, &c., *Comptes Rendus*, lii, 142.

† *Dingler, Polyt. Journ.*, clx, 23 and 120.

‡ Tellier, *Comptes Rendus*, liv. 1188. *Dingl. Polyt. Journ.* clxv, 450.

|| Pouillet, *Bull. Soc. d'Encouragement*, 1863, 32. *Ding. Polyt. Journ.* clxviii, 171.

§ *Ding. Polyt. Journ.*, clxiii, 182.

and figured. It was then and there announced that two German firms, Kropff and Co., of Nordhausen (since 1867), and Vaass and Littmann, of Halle on the Saale (since 1868), have taken up the manufacture of ammonia ice machines on Carré's principle. The former of these firms has now become a joint stock Ice Machine Company. According to the most recent quotations, both these establishments furnish the larger apparatus in five sizes, yielding from 25 to 500 kilos. of ice per hour at the price of 4800 to 30,000 reichsmarks (say from £240 to £1500). The Nordhausen Company manufacture also a small apparatus, for 7½ kilos. per hour, for 2250 marks (£112 10s.). According to their statements 1 kilo. of coal, according to the size of the machine, produces from 6 to 16 kilos. of ice.

The author in his treatise gives a calculation which verifies these statements. In the above-mentioned experiments with the hand machine 1 kilo. of charcoal yielded 3½ kilos. of ice. Vaass and Littmann give estimates of the first cost of the various machines, and of the price of the ice produced, which varies according to the size of the apparatus, producing respectively from ½ to 10 cwts. hourly, from 1 mark 15 pfennige to 20 pfennige per cwt., including interest on the capital, depreciation, and waste. The Nordhausen Company gives a calculation for a 250 kilos. machine based on 300 days' uninterrupted work (day and night), according to which the ice costs 36 pfennige per cwt. Up to the end of the year 1873 the latter establishment had finished 60 machines, 29 of them for Germany. Vaass and Littmann had completed 42 machines, 20 of which were for Germany, including 2 for Vienna.

At the London Exhibition of 1862, and that of Paris, 1867, Carré's machines were exhibited by Mignon and Rouart, of Paris; at the Vienna Exhibition the two German firms made their appearance.

Carré's machine is without doubt a very perfect, manageable, and effective apparatus for producing ice everywhere and to any extent. In many cases it may successfully compete with the natural article, especially in large towns where the demand is great, and where luxury plays an important part. Artificial ice is often more palatable, since natural ice is too fequently dirty, and even when perfectly clean possesses a swampy flavor. Among the ice manufactories whose existence we have ascertained, may be mentioned that of A. Pokorny, in Vienna, which was supplied by Kropff, in 1869, with a machine yielding 5 cwts. hourly. The proprietor has courteously informed

the author that he is perfectly satisfied with the working of the machine. It yields 10 cwt. ice per 1 cwt. of charcoal consumed. The cost of the ice amounts to 35 Austrain kreutzers per cwt., the sale price fluctuating from 70 kreutzers to 3 florins 20 kreutzers. The loss of ammonia amounts to 2 kilos. per 50 cwts. of ice produced. The machine has remained in good order for four years, but the connections are not perfect. Ice machines have been set up in various German breweries, to which the makers refer in their circulars. Mignon and Rouart are said to have made in 1869 a machine of the value of 20,000 florins (?) for the Joint Stock Brewery, at Deuxponts.*

Carré's machine has been from its very origin a very carefully constructed apparatus in which essential improvements are scarcely conceivable. The difficulty as regards the material was soon overcome by making all the parts of wrought-iron coated with zinc, copper, and its alloys being entirely avoided, as they are rapidly attacked by ammonia. Reece, however, in 1870, patented in England an improvement with the object of preventing the simultaneous evaporation of the water in the boiler. He asserts that the liquid which arrives in the ice generator consists of 25 per cent. of water and 75 of ammonia. His arrangement, which corresponds in the main with dephlegmation and rectification as customary in distilling, is said to condense the ammonia practically free from water.† He also utilizes the tension of the evaporating ammonia in a machine which works the pumps.

In September, 1867, Toselli, of Paris, obtained an English patent (in the name of Clark) for an ammonia ice machine arranged on the principle of Carré's portable apparatus. It consists of two cylinders, united axially by means of a tube, and turned continually by a handle. The ammonia contained in one of the cylinders gave off, when heated, its ammoniacal gas into the other cylinder ; the residual water afterwards re-absorbed the gas, the apparatus remaining all along hermetically closed. It was planned both for domestic use on the small scale and for manufacturing purposes. As regards its performance nothing has transpired.

Ammonia Air Pump Machine.—In 1869, Mort and Nicolle, of

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* *Dingl. Pol. Journ.*, cxciii, 432.

† Reece, *Dingl. Pol. Journ.*, 1870, 40. See also *Chemical News*, vol. xxxiii, p. 130.

Sydney, patented an ammonia machine* differently arranged from that of Carré's and capable of being regarded as a combination of the latter with the ether machine. The inventors use an air pump, but assist its action by absorption. As cooling agent they apply not volatilized ammonia, but concentrated aqueous ammonia.

The ammonia remains dissolved in the water only under the pressure at which it was saturated, and escapes in proportion as such pressure is diminished ; at the same time the liquid is cooled in a corresponding degree, as during the evaporation of pure liquid ammonia. Mort and Nicolle produce this decrease of pressure by means of the air-pump. The ammonia removed is condensed by the return stroke of the piston, and along with a corresponding amount of the diluted liquid simultaneously withdrawn from the evaporator is forced through a cooler, where re-absorption takes place. This arrangement requires less motive power than a pure mechanical condensation. It is to be expected that this ammonia machine should be more efficient than the ether machine, but its performance falls short of that of Carré's machine. More exact accounts are hitherto not to be had. The machine works at lower pressure than the ether machine, and like this must be carefully protected against the influx of air. The danger of explosion is removed from the machine itself and transferred to the boiler of the engine.

About the end of 1870 Mort and Nicolle patented a new ammonia machine, of which the only description in our hands is the English specification. It is described as the "low-pressure ice machine," and agrees in principle with Carré's machine, the air-pump being omitted. It differs, however, from the latter machine in as far as not liquid anhydrous ammonia, but a highly concentrated aqueous ammonia is produced and evaporated. This of course requires a much lower boiler pressure, the maximum tension being about 2 atmospheres at a steam heat of 107° C. The evaporation of course produces a much smaller reduction of temperature. The arrangement is such that the ammoniacal liquid steaming from above the ice generator, and flowing slowly over horizontal depressions, gradually loses its ammonia, and arriving at the bottom in a very reduced state of concentration is drawn out by means of a pump, and in a especial vessel re-absorbs the ammonia which has been expelled by the heat. The liquid restored to its original degree of concentration is

* Mort and Nicolle, *Mech. Mag.*, 1870, 189. *Dingl. Pol. Journ.*, cxcvii, 311.

pumped back into the ice generator. The liquid escaping below from the kettle, and which is little more than water, serves as in Carré's machine for the re-absorption of the ammonia evaporating from the ice generator, and is driven back into the boiler by a second pump. It must be mentioned as a specialty that the ammonia evaporating in the boiler passes first into a cylinder with a piston, and furnishes the power for working the pumps, whereupon the absorption takes place.

(To be continued.)

A LECTURE ON LENSES.

By Joseph Zentmayer.

(Continued from Vol. ci, p. 347.

So far we have considered a ray of light, refracted by a transparent medium, to be still a single ray. Such would be the case were the white ray of light of a single homogeneous color; but what we call white light is composed of different colored rays, which by passing through a refracting medium, are refracted in different degrees. This is the source of another aberration of even more importance than the spherical aberration—the chromatic aberration. By passing a beam of white light, *B*, (Fig. 16) through a prism, it is not only refracted, but decomposed into seven colors, red, orange, yellow, green, blue, indigo and violet. These different colored rays are differently refracted by the prism. The violet ray, as the most refrangible one, is refracted towards *V*, and the red one, as the least refrangible, is refracted towards *R*, and other colored rays fill out the space between *V* and *R* in the order of their refrangibility. This is known as dispersion. The dispersion of refracting medias is measured by the length of the spectrum which they produce. Flint glass has more dispersive power than crown glass, because the spectrum which it produces is longer than that of crown glass. The dispersion of a medium is indicated by the difference of refraction between the index of refraction of the red and the violet. Let us now see what effect the dispersion has on images produced by single lenses.

Fig. 16

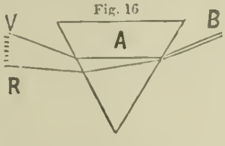
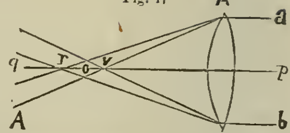
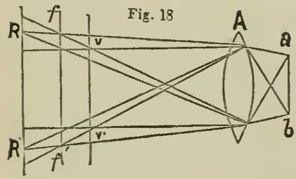


Fig. 17



White light *a* and *b* is falling on a double convex lens (Fig. 17). The ray *a* is decomposed into the different colored rays as soon as it enters the lens, and the red ray, as the least refracted, will cross the axis *p q* in *r*, while the violet ray crosses the axis in *v*. Between the red and violet the other colored rays cross the axis. The same is with the ray *b*, and if we do not consider the spherical aberration of the rays between *a* and *b*, all the red rays will have their focus at *r*, and all the violet ones at *v*. Between *r* and *v*, the foci of all the other colored rays are situated. The space between *r* and *v* is called the longitudinal, chromatic aberration. The length of the aberration changes with the dispersive power of the media, out of which the lens is made; it is, for instance, twice as great if the lens is made of flint glass, as if the lens were made of crown glass. The influence of the chromatic aberration on the image of a lens is shown in Fig. 18.

Fig. 18

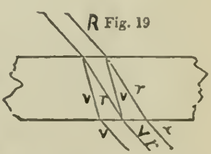


The white light from the object *a b*, refracted and dispersed by the lens *A*, does not form a colorless image at *f f'*, but the red rays form one at *R* and *R'*, and the violet at *V V'*. But between there, an endless number of colored images of rays of different refrangibility are produced. The red image is the largest. If we place a screen at *R R'* we do not get simply a red image, as all the other dispersed images are formed on the screen; and as the mixing of all the different colors of the solar light make white light again, so the mixed images, that is, the central part is colorless and only the margin is blue, because it is surrounded by the diffusion image of the blue diverging rays.

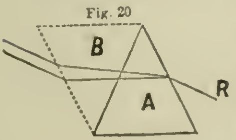
If the screen is moved to *V V'*, then the image is surrounded by a red margin; if it is moved to *f f'*, the colored margin disappears, but the image, composed of the different dispersed images, appears undefined and not clear. This effect is more increased because each colored image has its spherical aberration also. Chromatic aberration alone would place the different colored images in regular succession behind each other, but spherical aberration mixes these images of different colors, and only the two outer ones, red and violet, remain. From the foregoing it is clear that chromatic aberration must necessarily interfere with the definition of a lens, and that it is desirable

to find a way to correct this evil. From the moment when Newton unraveled the nature of solar light, proving that light is composed of rays of different refrangibility, our greatest philosophers and opticians have spent their time and skill in the attempt to produce lenses without chromatic aberration, or at least to reduce it to a minimum. Sir Isaac Newton was of the opinion that refraction and dispersion of different refracting substances are always in the same ratio to each other, and concluded, that it was hopeless to produce refraction without color, by combining convex and concave glasses. Leonhard Euler, the great mathematician, on the other hand, reasoned in another way, and this is a curious instance of how a correct conclusion was drawn from false premises. He assumed that the human eye is achromatic, and consequently a lens could be made achromatic too, and Newton must be in error; he constructed theoretical rules for making achromatic lenses, and Dollond, the optician, succeeded in carrying them out. But Dollond, by comparing the eye with his lenses, observed that the eye cannot be achromatic, and Fraunhofer afterwards measured the chromatic aberration of the human eye, and found that an eye, that is able to bring parallel rays of red light to focus on the retina, can only bring violet rays to a focus, coming from a distance of two feet.

Now let us see how we get rid of these beautiful colors, which we admire so much in the rainbow and the glittering dewdrop, but which hurts the eye of an optician, in an optical instrument. If a ray of white light, *R* (Fig. 19), falls obliquely on a parallel plane glass, it is decomposed as soon as it enters the glass; but on the other side all the colored rays which made white light, are, on leaving the glass, parallel to its former direction, and if we think the whole surface of the glass struck by white rays, they all will be dispersed, and come out parallel on the other side; but, if the different colored rays are mixed homogeneously, it makes white light again.



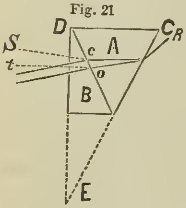
But if a prism, *A* (Fig. 20), is struck by an oblique ray, *R*, the ray is dispersed in the glass, and the colored rays leave the prism diverging, and they cannot be properly mixed again to white light, except we can give to the leaving rays their parallelism again. Now, if we combine a prism,



B, of the same angle and material, in a reversed position to *A*, it is evident that we restore the diverging rays again to parallel rays; but, unfortunately, we destroy not only the dispersion, but also the refraction,—we make a thick, parallel glass out of the prism.

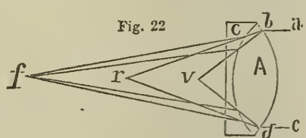
Let us try it in another way. The ray, *R* (Fig. 21), passes into a prism of crown glass, *A*, and a colored image would be formed at *s t*, if the prism *B* would not interfere. If we now could combine with the prism *A*, one of a less angle, but made from material like flint glass, of greater dispersive power, so as to have the same dispersive power as the larger angle prism *A*—we can restore the diverging into parallel rays, and the light will come out white again, although it went through the compound prism *C D E*. This is perfectly practicable, if we make the prism *B* of flint glass; this having a greater dispersive power than the crown glass, and the rays *c* and *d*, when entering the prism *B*, are somewhat refracted—the violet more than the red—and their divergency is smaller; and, if the prisms have the right proportions, the red and violet rays come out into the air parallel, and, at the same time, the rays passing from the prism *B* will have a different angular direction than that with which they entered the prism *A*. Thus we have refraction without dispersion.

Fig. 21



Let us adapt this principle to a lens, *A* (Fig. 22), made of crown glass. The rays *a* and *c* enter the lens at *b* and *d*, and are dispersed; the red would cross the axis at *r*, and the violet at *v*. We associate the plano concave *c*, of flint glass, with the lens *A*. As the negative flint lens is of a denser medium, the violet, as well as the red rays, will be refracted, but the violet more so than the red; and, if form and dispersive power of the two lenses are in the right proportions, the red, as well as the violet, will meet at the point *f*; the image formed there, is colorless, or achromatic, or, in other words, it will appear in its natural colors. But even in the best achromatic lenses there is still a small amount of color left, which cannot be destroyed. If we compare the spectrum of a prism of crown glass, with one of flint glass of the same angle, we find that the more refrangible blue, indigo and violet, take not only absolutely, but also relatively, more space than one in the spectrum of the crown glass

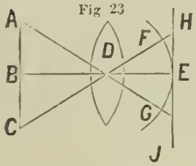
Fig. 22



prism. So, if we succeed in uniting the outer rays, red and violet, the intermediate colors cannot unite completely, and this remainder of not corrected colored rays we call the secondary spectrum. Complete achromatism, therefore, cannot be obtained, but we must be content to come as near as possible to the requirements. A selection of crown and flint glass, in which the proportion of length of the spectra of the different rays are nearly related, will bring us very near to our purpose. Fortunately, the colors of the secondary spectrum are feeble, and do not interfere much with the sharpness of the image, and we are well pleased if a lens exhibits only the secondary colors—light purple and greenish, as it is a proof that the most objectionable effects from chromatism are removed. The association of flint and crown glass serves not only to correct chromatic aberration, but, as we have seen before, if the right form for each of a pair of lenses be selected, it corrects spherical aberration also. Such a lens, corrected for spherical and chromatic aberration, we call an *aplanatic* lens.

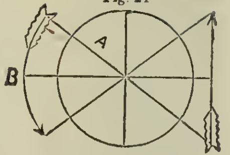
We now come to another aberration of a lens, the curvature of field. The image of a flat object, formed by a lens, cannot be received on a plane screen; the screen ought to be concave. A, B, and C (Fig. 23), are very distant points, and, therefore, nearly equal distant from the lens D, of which the point B is situated, in the line of the axis of the lens, while the points A and C are above and below the axis. It is evident that the images of these points are formed at nearly equal distances from the optical centre, not far from the principal focus. The field FEG is therefore curved, and cannot be received on the screen HI equally sharp. The curvature of field is generally attributed to spherical aberration; sometimes it is even thought to be spherical aberration itself, but it has nothing to do with it. If lenses could be made with parabolic curves, free of spherical aberration, the curvature of field would be about the same.

Fig 23

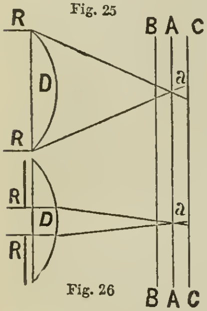


Suppose we have a globular lens A (Fig. 24), with a diaphragm in the middle, so small as to reduce spherical aberration to almost nothing. Now we know that the focus of a sphere of crown glass is situated $\frac{1}{4}$ of the diameter behind the globe, at B, and as all the pencils are normal, they all will form their image $\frac{1}{4}$

Fig. 24



of the diameter of the globe behind it; that is, the image lies in a curve, concentric with the lens, although the spherical aberration is not perceptible. To understand the correction of the curvature of field, we must make clear what is meant by depth of focus, and what the effect of a diaphragm is. Depth of focus is the property of a lens, to give a tolerably clear image of objects, not in one plane. Figs. 25 and 26 will make it plain. In Fig. 25, we make use of the whole aperture of a lens *D*; *R R* are parallel rays, striking the margin of the lens. The image is formed at a screen *A*; if the screen is moved to *B* or *C*, the image of the point *a* spreads out, because the angle of the crossing rays is large. When the same lens, *D* (Fig. 26), is provided with a diaphragm, so as to reduce the aperture considerably, the focus of the rays *R R* is still at *a*. If we now move the screen the same distance as before, to *C* or *D*, we find that the image of the point *a* is considerably reduced. If we now look at Fig. 23, we see that only *E* can be sharp on the screen, and if the screen be moved towards the lens until the points *F* and *G* are sharply defined upon it, then the point *E* will lie beyond the screen and become indistinct; but if we provide the lens with a small central diaphragm, we can find a place for the screen, where all three points can be brought to it, without the images being sensibly diminished in sharpness.



Now let us see what takes place, if we move the diaphragm to a proper distance from the lens. *A*, *B*, *C* (Fig. 27), are distant points, *L* a converging lens. Let us trace the course of the rays, commencing from the points *A*, *B*, *C*. The rays from he points *B*, situated in the axis, and the image of the point *B* will be formed at *F*, the principal focus. But it is different with the rays coming from *A* and *C*. The rays proceeding from the point A—A_{i}, A_{ii}, A_{iii}, A_{iv}, A_{v}, are refracted to *a*, *b*, *c*, *d*, *e*; similarly the rays from the point *C* are refracted to *a′*, *b′*, *c′*, *d′*, *e′*; occasioning, as we have seen

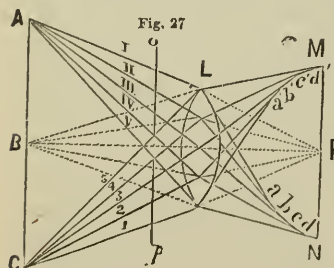
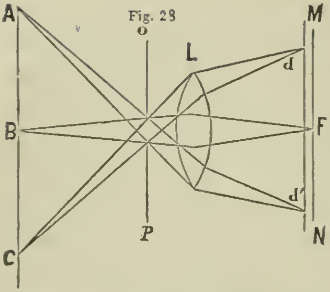


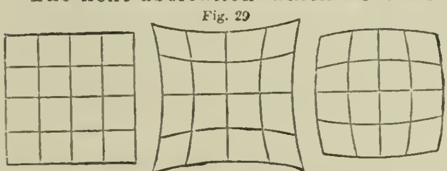
Fig. 28



before, spherical aberration. If we place a screen at the principal focus F, it will not receive a distinct image, even if we have a concave screen; as will be observed, all the rays outside of the axis arrive at different distances behind the lens. You notice that none but the rays A_{iv} and A_{v}, and C_4 and C_5, have their focus near the plane of the screen $M\,N$. Now if we find a place for a diaphragm, so that only these rays pass the lens, and the depth of the lens is as great as $d\,M$, we may expect a pretty sharp image on a plane screen. By looking over the figure, we see that such a plane is in $O\,P$ (Figs. 27 and 28). A diaphragm in this place, and of the proper size, will allow only the most favorable rays to pass, and a tolerably flat and sharp image is obtained. The smaller the diaphragm, the sharper and flatter the image. But as we mentioned before, small diaphragms have the disadvantage that the light is cut off to such an extent; and for most purposes the lens becomes useless. But suppose we would employ a negative lens, under the same conditions, we would have no real image, but a virtual one, the curvature of the field would be reversed, and the marginal rays have a longer focus than the central ones. Therefore, it is possible to associate a negative with a positive lens, and to render the field flat.

The next aberration which we have to deal with, is the distortion.

Fig. 29



If we describe a network of straight lines, and hold a convex lens over it, placing the eye at a distance from it in the axis of the lens, only the two right angle lines of the centre appear straight; the others appear curved. When the upper is in the reverse position to the lower one, they appear pincushion shaped. When distortion of the negative lens is reversed, the lines appear as the curved sides of a barrel.

The cause of distortion is somewhat difficult to explain, but the fol-

Fig. 30

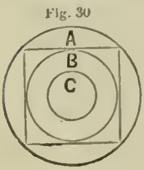
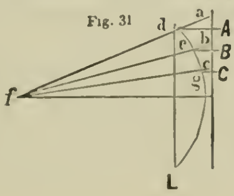


Fig. 31

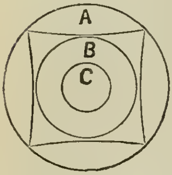


lowing figures make it clear. Let us describe upon a plate or plane surface a number of circles, A, B, C, equidistant from each other (Fig. 30 in front view, and Fig. 31

in profile), and place in front of them (Fig. 31) the lens *L*. Now the rays which proceed from *A*, *B*, *C*, parallel to the axis of the lens, strike it at *d*, *e*, *g*, from whence they will be refracted, and meet at *f*, the principal focus. If we place the eye at *f*, we see the circle *A*, not where it really is, but in the direction *f d*, the circle *B* in the direction *f e*, and the circle *C* in the direction *f g*. By prolonging the lines of directions, until they meet the plane of the circles *A B C*, we observe that the circles do not appear equally apart, but their distance is increasing from *C* to *A*; they will appear as in Fig. 32.

We will suppose for a moment that the circles *A* and *B*, (Fig. 30), are of such relative diameters, that a square inclosing *B*, with its sides tangential shall have its corners in the circle *A*. Now if we draw the circle *A* and *B*, (Fig. 32), (as they will *appear* from *f*), the distance between *A* and *B*, will be greater, or equal to *a b*, (Fig. 31), and as the contact of the side of the square with *B*, (tangentially), and with *A* at the ends must be kept, the line of the side will now *appear* curved or bent (Fig. 32).

Fig 32



A single lens without distortion cannot be made, but by combining two or more lenses in connection with diaphragms in a certain position, the distortion may be corrected completely. If a diaphragm is placed in front of a lens *L* (Fig. 33), different parts of the lens are employed to form different parts of the object *C D*. In this case the distortion is barrel shaped, but by placing the diaphragm behind the lens, as in Fig. 34, the distortion is of the opposite nature, that is, pincushion shaped. Rays coming from *D* (Fig. 33), pass through the upper part of the lens, while in the latter, through the lower part.

Fig. 33

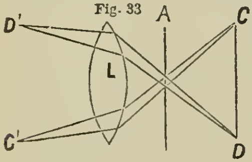
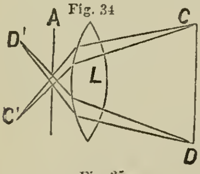
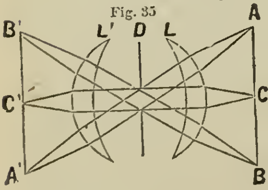


Fig. 34



Now you will readily see, that by uniting two lenses, equal to each other, *L*, *L′* (Fig. 35), and placing a diaphragm *D* between them, it follows that the distortion accompanying the lens *L*, with its diaphragm behind it, is corrected by the action of the same diaphragm, upon the rays entering the lens *L′*, where the diaphragm is now in front of the lens *L′*. The modern photographic objectives to be used for architectural work and copying, are constructed on this principle.

Fig. 35

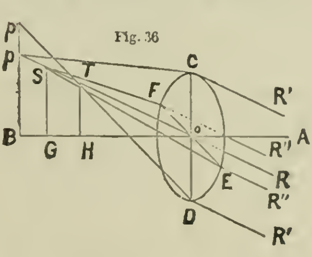


Unfortunately this advantage is obtained at the sacrifice of aperture, that is, of light. I mentioned before, that the negative lens has the opposite distortion of the positive lens, so that by proper combination of lenses of suitable curves and material, distortion can nearly be overcome upon a limited field.

Photographic objectives used for portrait purposes, when a large quantity of light is desirable for brief exposure, are thus corrected; but these are again open to the fault of a restricted angle of vision. In all other lenses when the light is the desirable element to be preserved, the correction of distortion must be made, as far as possible, by a combination of lenses.

We come now to the last of the more important aberrations, that is the astigmation, a word coming from the Greek, meaning: not coming to one point. If we focus a well defined, round object, situated in the axis of a lens of a wide aperture, on a screen, we find the image round, even if we move the screen in and out of the focus, the image will get only less sharp; but if we turn the lens sideways, so as to get the image of the same object formed by pencils oblique to the axis, then we will observe that it is no longer possible to form a sharp image of the object, and by moving the screen in and out of the focus, the image appears elongated, horizontally or vertically.

Fig. 36



Now let us see whether it can be made clear, in the following figure (36). CD is a convex lens, of which $A\,B$ is the axis. The lens is represented in perspective, as we have to show two planes, in different directions. The radiating point R is situated at infinity, and outside of the principal axis. We will lay a plane through the axis $A\,B$, and the point R, which will cut the lens in its diameter $C\,D$. Let us lay another plane through the point R, at a right angle to the former, and which will cut the lens in its diameter $E\,F$. If we draw the line $R\,p$ through the optical centre of the lens, a ray following it would not be refracted, as we have seen before, and constitutes a secondary axis. $R\,p$ is the line where the two planes cut each other, and consequently belongs to both planes Let us draw the two extreme rays, $R'C$ and $R'D$, of the diameter CD' which, after refraction are T and p', as we learned by analyzing spherical aberration. If we now look to the other plane, the rays

$R'' F$ and $R''E$ are symmetrical to the axis, and are exactly equally refracted, meeting at the point S. If the lens is now diaphragmed down, so as to improve the aberration of the plane CD, we find that we have for one lens two distinct foci. If we focus, for instance, a brick wall, we will have the horizontal white mortar lines in focus, while the vertical ones are out of focus, and *vice versa*. By looking to the figure, you can easily see that that universal doctor in optics, the diaphragm, will also cure astigmation, at least will bring it to a minimum. Fig. 35 will suggest a way by which astigmation may be destroyed almost completely. The diaphragm D divides the lens L into an infinite number of lenses, of which each acts on a different radiating point, and the pencils in or out of the axis, strike the lenses almost normal, hence such a combination is not only nearly free of distortion, but of astigmation also.

Many of you are aware that in nearly all human eyes there exists an aberration, also called astigmation. Although in its effect similar to the astigmation of lenses, just mentioned, it is of a different character. Nature intends that the curves of the cornea and crystalline lens of the human eye should be spherical; but the exceptions seem to be the rule. The curves of the cornea and crystalline lens of the eye are in nearly all cases, more or less elliptical, egg-shaped, and consequently have in one meridian a longer focus than in the other. If such an eye brings the image of a line parallel to one meridian, to a focus at the retina, the images of lines parallel to all the other meridians, do not collect at the retina, especially the one at right angles to the former, and a distorted, blurred image is the result. The advancement of science has lately enabled our oculists to correct this evil by spectacles, of which the glasses are parts of cylinders, instead of spheres.

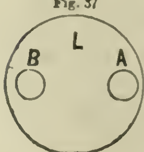
Now, knowing all the defects of lenses, and the different modes of correcting the same, let us look back to that primitive instrument—the pin-hole camera. The pin-hole camera is free from all the errors, as spherical and chromatic aberrations, distortion, curvature of field, astigmation; and the only objection against it is the extremely small aperture. What an amount of speculation and hard labor of the most eminent men were necessary to furnish a substitute, equally free from errors, having a larger aperture, giving a brighter image. And, even now, none of the aberrations can be completely corrected, and the best that can be done, and that for a limited aperture only, is to

reduce the errors so far as to diminish their extension, so as to make them appear to our eye at a smaller angle than the eye is able to distinguish. In lenses used as objectives, where the image is magnified by high eye pieces, even that is extremely difficult, as the errors are also magnified. Our most celebrated opticians, such as Fraunhofer, never attempted to give a telescope objective a larger aperture than the focus divided by ten, except in very small pocket telescopes. And his larger telescope, the one he made for the Dorpat Observatory, and which he considered his best objective, has a focus of 160 inches, while the aperture is only 108 lines, that is 1-17th of the focal length, and its highest magnification is 720 times. The larger telescopes of Dollond are nearly twice as long. The same artist, Fraunhofer, took precaution to warn young opticians and amateurs not to listen to the very natural desire to try their skill on larger apertures, and giving higher magnification, if they do not wish to be disappointed, and lose time and money. But the school of experience seems to be the only one to cure this desire.

But here I feel bound to mention that a few years ago, Mr. Steinheil, of Munich, read a paper before the Academy of Sciences of that city, on an improved telescope objective. It is composed of four lenses—one positive crown glass lens, combined with a compound negative lens, which itself is a triplet of two flint and one crown glass lenses. By this formula, a 4-inch telescope is only two feet long, while in the ordinary way it is twice as long.

While I am speaking about wide apertures, I cannot pass without mentioning a very serious obstacle connected with large apertures; it might be called the parallactic error. I was frequently asked why a large photographic objective does not give the same sharp image that a small one does. It is somewhat more difficult to correct a large objective than a small one, even if the aperture stands in the same relation to the focal length. But it is not only this. Suppose we have a large photographic objective, say of six inches aperture, L (Fig. 37). Each part of the lens receives radiating rays from each point of the object,

Fig. 37



and brings them to a focus at the respective place. Now, if we cover the lens by pasting paper over it, leaving only the aperture A free, we still get an image, only more feeble in light. Again, cover the aperture A, and open the aperture B, you get an image of the same object; but the apertures A and B are say four inches apart.

Both cannot give precisely the same image, as they are taken from another base. The images will be similar to the two images of a stereograph, which are taken in a similar way by two lenses. Now open both apertures, A and B, and as the images are not equal, they cannot cover each other, but will overlap, especially the images of the nearer objects. If we now use the whole aperture of six inches diameter, it is clear that we will have an infinite number of images none equal to the other; every one overlapping the other, and the image, necessarily, must be a blurred one. For this there is no remedy but cutting down the aperture.

Ladies and Gentlemen, we have now a reasonable knowledge of what a lens is, and I would like to go over to the more interesting part of optics—to the combinations of lenses—such as the telescope, the microscope, and camera, which not only have given us so much pleasure, but have enlarged our knowledge so wonderfully; but this would require more time than we have on hand to-night, and I will not tax your patience any longer, but thank you for the attention you paid to the rather wearisome subject, and for the interest with which you followed the lecture during the evening.

Gramme Machine for Illumination.—From *The Telegraphic Journal*, April 15th, 1876.—Experiments in electric lighting have been continued at the Northern Railway Station, Paris. We hear that the Northern Company will, if these trials are satisfactory, light the arrival shed by electricity. This shed has a cubic space of about 300,000 cubic metres. For this purpose four electric lights will be used, rather more powerful than the one used in the luggage rooms and the custom house, which is employed from five o'clock till midnight. At the trials of which we speak a Gramme machine was being used, giving a light equal to 100 jets of gas, consuming 150 litres an hour. Lately, experiments with the photometer and dynamometer have been carried on at the lamp factory of Messrs. Sautier and Lemmonnier. The result of the trials show that this powerful Gramme machine gives a light equal to 1,850 Carcel burners. The equivalent consumption of oil would be (reckoning 40 Grammes an hour per burner) 71 kilogrammes an hour; of gas 194 cubic metres, say about 650 kilogrammes of coal. The cost of electric lighting is about one-hundredth part that of oil.—*Moniteur Industriel Belge.*